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ENGINEERING INTERNSHIP FINAL REPORT

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Recipient: Dr. A. H. George, M&IE Department at Montana State University

Submission Date: September 9th, 2019

ABSTRACT

This report contains details regarding my work experience during the summer of 2019 at Los Alamos National Laboratory in Los Alamos New Mexico as an undergraduate facilities engineering intern. My projects were categorized as follows:

Project Name	Individual or Team	Technical Area	Building Number	Building Name	Primary Conclusions
TA-03-1420 "Smart Lab" Renovation	Team (5 ppl.)	03	1420	CINT	47% energy savings could be accomplished with all offices reduced to five air changes per hour (ACH), Laboratories averaging seven ACH, all lighting switched to LED bulbs, and an energy recovery system installed in the second-floor mechanical room. This project would have a discounted payback period of approximately ten years.
0223 HVAC Renovation	Individual	03	0223	Tradesman Offices	This building requires a ten-ton air handling unit to service its cooling and heating needs. Along with this unit, new ducting must be placed above the acoustical tile ceilings to properly service the tenant spaces.
Life-Cycle Cost Analysis for TA-15	Individual	15	N/A	Trailer Offices	Natural gas power for office ventilation would not be cost effective in a temporary setting (six years), but would be considered cost effective in a permanent setting (ten or more years).
Life-Cycle Cost Analysis for TA-16	Team (2 ppl.)	16	1555	Fire Station 5	A solar PV array on the roof of the fire station is cost effective and contributes to federal energy requirements.
SM-30 HVAC Study	Team (2 ppl.)	03	0030	SM-30	Tenants in this building are not properly serviced heating and cooling needs. Comfort and productivity would be improved with new air handling units, new ducting, drop-down acoustical tile ceilings, and LED lighting.

<u>TA-03-1420 "Smart Lab" Renovation:</u>

This project was the main focus of the summer, and was completed by a team of five undergraduate students (fields of study included mechanical engineering, architectural engineering, electrical engineering, and chemistry). The seven concepts of a "Smart Lab" were developed by the University of California Irvine as part of the Department of Energy's (DOE) Better Buildings initiative. The students were assigned to the Center of Integrated Nanotechnology (CINT) at LANL to implement as many of the

Smart Lab components as possible, and provide a comprehensive design recommendation for LANL to implement with the next five to ten years. These components are classified as (1) lowering system pressure drop, (2) demand-based ventilation, (3) dynamic digital control systems, (4) fume hood air flow optimization, (5) exhaust fan discharge velocity optimization, (6) demand-based LED lighting with controls, and (7) continuous commissioning with automatic cross platform fault detection. To implement these concepts, the student group identified three main design areas, and several other areas for recommended further study. Theses design areas were classified as facility HVAC, lighting, and fume hoods. The students concluded that modifications made to reduce air changes, install an energy recovery system, and optimize fume hood ventilation, would save up to 47% energy consumption and could be achieved with a ten-year discounted payback period. My specific role with this project involved project management, heat load calculations, energy saving calculations, directing weekly team meetings, and addressing other tasks as needed by the group.

0223 HVAC Renovation

The TA-03-0223 HVAC renovation was assigned as an exercise where I accompanied a current facility engineer during walkthroughs of the facility and helped with design aspects. I performed heat load calculations using Microsoft Excel spreadsheets distributed by ASHRAE. I also participated in sizing the air handling unit to be used and ordering the unit from a manufacturer.

LCCA for TA-15 and TA-16 Projects

Formal and documented life-cycle cost analysis was brought to me as a time-consuming issue that was often neglected by LANL engineers. As part of this task, I created and developed an Excel workbook for automated calculations for any project or components of projects involving facilities and utilities. This spreadsheet automated the process outlined by the National Institute of Standards and Technology (NIST) Handbook 135, and used government-specific rates and quotes for calculations. Completion of this tools provided information regarding the initial investment, annual cash flows, discounted payback period, present values, and the savings-to-investment ratio. After piloting this spreadsheet with the temporary office trailers from TA-15 and the fire station project for TA-16, I created a blank template and presented this to almost all the Project Engineers at the Lab. This spreadsheet was also used for the *CINT Smart Lab* project.

SM-30 HVAC Study

The SM-30 study consisted of three hours of walkthroughs, heating and cooling load calculations—done in the same fashion as done for the *CINT Smart Lab* and the *0223 HVAC Renovation*—and a brief write-up of the observed current conditions for the facility. I primarily began this project four days before I left LANL to return to Montana State University, and do not have material to include in this report due to the Lab's security policies. This project is being continued though Engineering Services at LANL to adjust SM-30 to the current ventilation demands.

TABLE OF CONTENTS

INTRODUCTION

The following report details my experiences as an undergraduate Mechanical Engineering intern at Los Alamos National Laboratory (LANL) during the summer of 2019. I worked with supervisors from both the Capital Projects Division (ALDCP) and Engineering Services Utilities and Institutional Facilities (ES-UI). Mentors and staff within these groups were effective resources to help me successfully complete engineering projects regarding HVAC design and renovation, energy efficiency, systems engineering, and supporting project documentation. The work environment was open to questions, formal for presentations, and casual for student group work. I was surrounded by kind people who enjoyed being at work, which motivated me to feel the same way.

DETAILED DESCRIPTION OF WORK

WEEKS 1-2: MAY 13TH – MAY 24TH

My first impression of my workplace at Los Alamos National Laboratory was the friendly people and their passion for helping students learn and prepare for work after college. Initially, members of the Smart Lab group had not yet arrived, so I was tasked with new employee trainings, research of HVAC concepts, and completing the first draft of a life-cycle cost analysis Excel calculator.

LANL's new employee trainings addressed safety, security, technology, payroll and workplace expectations. This involved workshop presentations, online modules, and a proctored exam. After completion of this training I felt prepared to work at LANL and knowledgeable about general company processes.

Knowing my future projects would involve heating, ventilation, and air conditioning (HVAC), I reviewed thermodynamic concepts and calculation methods using and ASHRAE training manual provided to me by my mentor. As I walked through the manual, I researched videos and articles further explaining HAVC components such as centrifugal fans, compressors, ducting layouts, dampers, etc.

With the Utilities and Institutional Facilities group being one of my employers, I was presented the problem of life-cycle cost analysis, as explained by NIST Handbook 135. LANL engineering standards required all facility projects to undergo this analysis during the conceptual design phase to ensure quality of the project and compliance with federal energy requirements. The handbook provided to me was the current source for engineers at LANL, dating back to 1995. Though software could be purchased to complete this analysis, I was tasked to create a user-friendly Excel version for distribution throughout the Engineering Services Division. This version was asked to simplify the worksheets provided by the handbook, automate all calculations, use government-specific rates, and allow customization by the user. Ultimately, if successfully developed, the spreadsheet would save LANL engineers hours of work and motivate more thorough analysis. The initial stages of this life-cycle cost analysis spreadsheet were made to compare energy sources of pure electric against electric/natural gas mixed to the facility. Initial examples used to check correctness were provided in the handbook. After having the initial draft, the file was presented to two engineers and one program manager for comments and to determine next steps. They gave me helpful feedback and were delighted with the result of the spreadsheet.

See *Figure 1* below for the link to both Life-Cycle Costing Manual for the Federal Energy Management Program, NIST Handbook 135, 1995 Edition and Energy Price Indices and Discount Factors LCCA 2019, Annual Supplement to Handbook 135 used for this project. See *Appendix B.1* for publication of an early version and example of this spreadsheet.

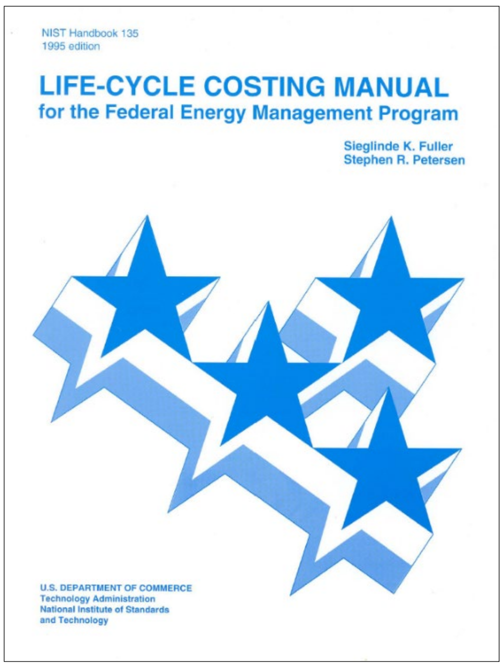


Figure 1: Cover Page for NIST Handbook 135, found at https://www.nist.gov/publications/life-cycle-costing-manual-federal-energy-management-program-nist-handbook-135-1995. Annual supplemental discount rates found at https://www.nist.gov/publications/energy-price-indices-and-discount-factors-life-cycle-cost-analysis-150-2019-annual

WEEKS 3-4: MAY 27TH – JUNE 7TH

Upon the third week of my internship, most of the Smart Lab team was present and a meeting was held to thoroughly define the scope of our project to us. Our deliverable was defined as a final presentation, Student Symposium Poster, and design package proving the design scope of the CINT Smart Lab project for future implementation. This implied the seven components of a UC Irvine Smart Lab, project management paperwork, and engineering analysis be implemented to the best of our abilities. To do this, we were provided contact information of about ten subject matter experts (SMEs) to ask questions, baseline information about the current facility conditions of CINT, and example project management documents. With this scope defined and expectations laid out, we assigned "roles" throughout the group. My roles were Co-Project Manager (PM) and Co-Project Engineer (PE). These positions allowed each team member to understand their general responsibilities and contributed to an easier flow of the project. The time period of May 27th – June 7th was used as the preliminary research phase of the design process, where we acquired engineering tools, facility information, went on several building walkthroughs, met with building tenants, and met with SMEs to gain knowledge of potential design areas.

My specific responsibilities as PM included scheduling, such as creating and updating our Gantt Chart with self-made deadlines, setting up meetings with SMEs, directing team meetings twice a week (at the start and at the end of the week), as well as motivating the team to stay on task. My specific responsibilities as a PE included co-directing building walkthroughs, understanding each design area being perused, performing in-depth heat calculations, analyzing potential energy savings, and performing life-cycle cost analysis for all HVAC components and the total Smart Lab recommendation as a whole.

Engineering tools acquired at this time and used throughout the project were Microsoft Suite, Microsoft Projects, GSuite, AutoCAD, SkySpark, ASHRAE 90.1, ASHRAE HVAC Excel Calculators, 2019 ASHRAE Training Handbook, MATLAB, and the building automation system (BAS) Alerton Compass. We also had records for CINT regarding energy consumption, maps of all utilities provided to the facility, and all engineering, architectural, and structural AutoCAD files for CINT. See *Figures 2-5* below for important components found during our preliminary research phase:

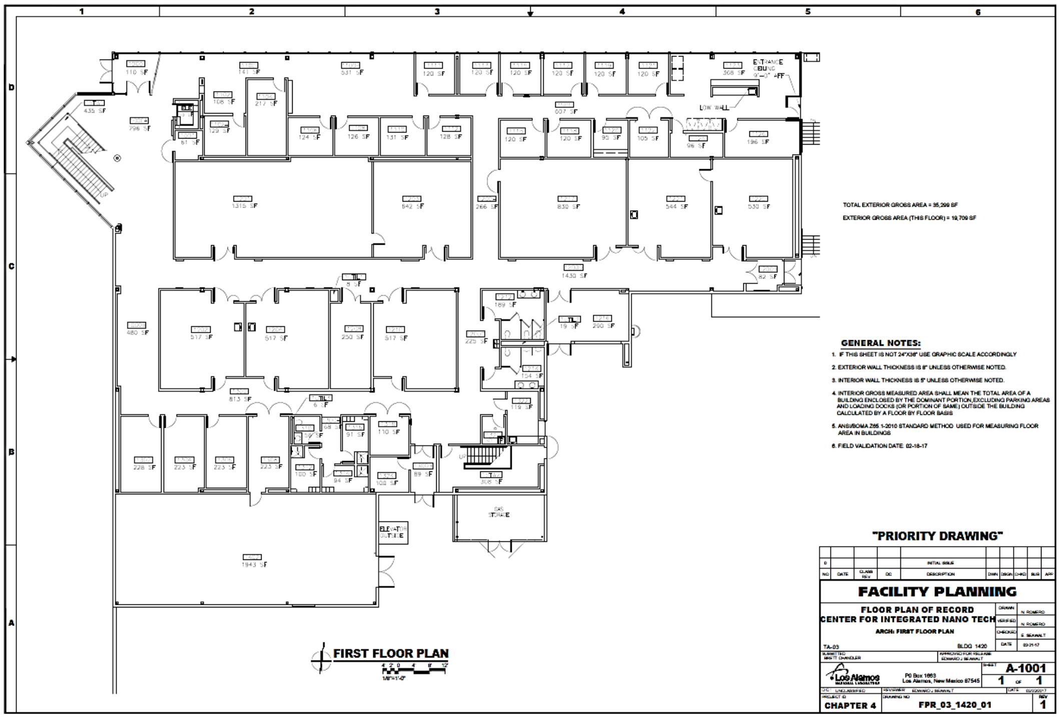


Figure 2: TA-03-1420 (CINT) First Floor Plan

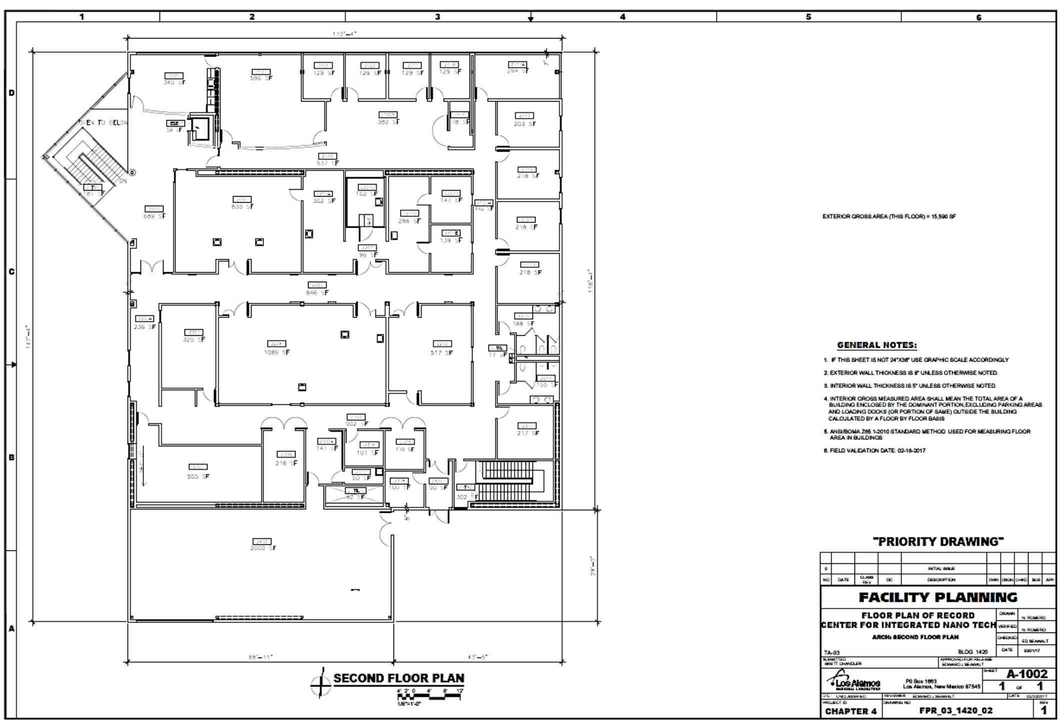


Figure 3: TA-03-1420 (CINT) Second Floor Plan

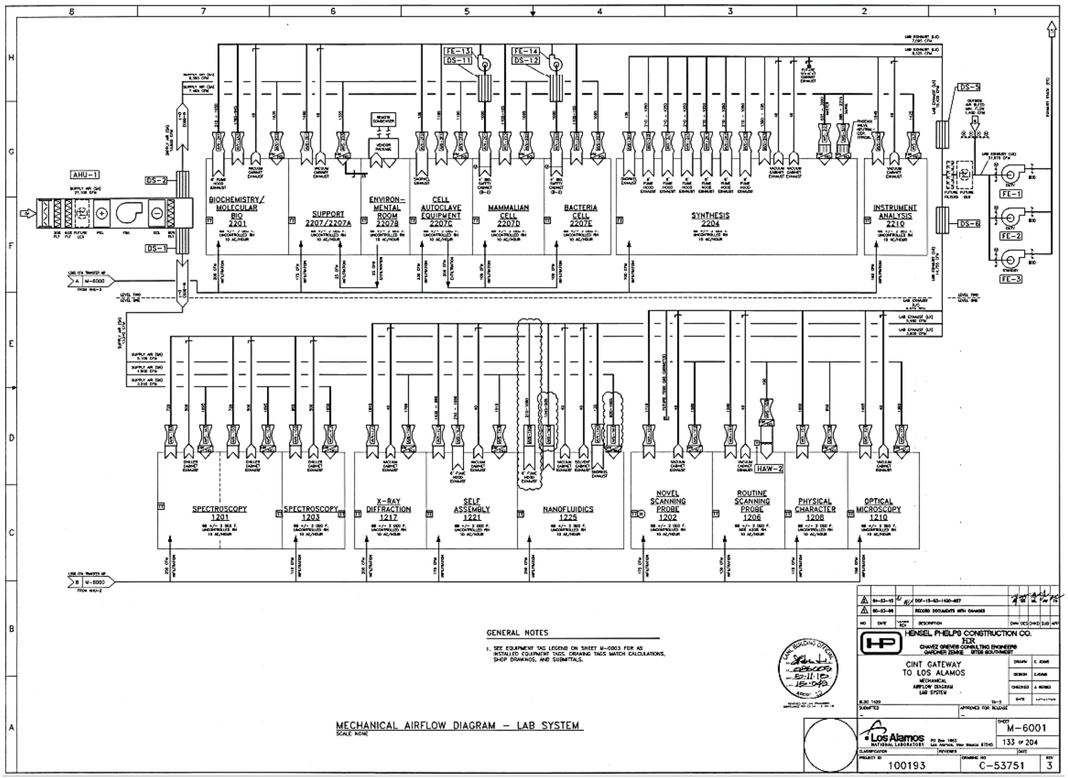


Figure 4: TA-03-1420 (CINT) Mechanical Air-Flow Diagram – Lab System

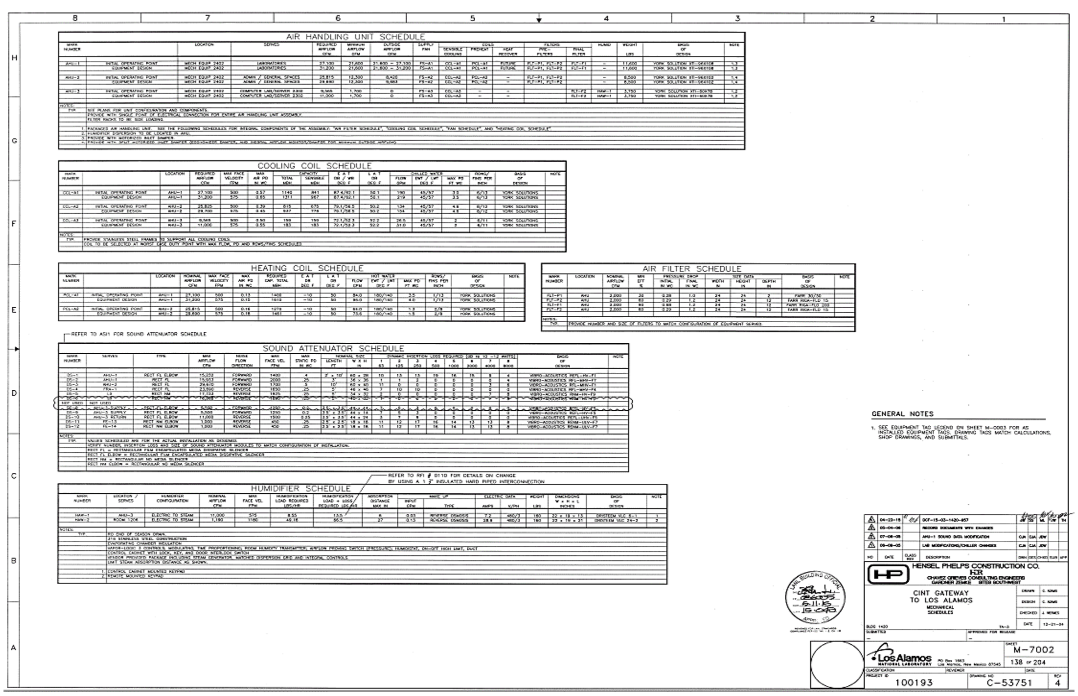


Figure 5: TA-03-1420 (CINT) Air Handling Unit Schedule

Regarding the LCCA projects at this time, the TA-15 Office Trailers analysis began and the first example LCCA Spreadsheet was completed and revised for comparing energy sources (see *Appendix B.1*). The analysis of the TA-15 Office Trailers was used as the first pilot case, and I had to get information from that project's estimator, project engineer, and also the utility usage of another office trailer to compare energy needs. Gathering this data for line-items within the spreadsheet was challenging because it required responses from other people in different parts of the Lab. Due to this reason, as well as updates made to the spreadsheet and a primary focus on the Smart Lab, the LCCA was not completed for this project until week eleven of my internship. Though this took longer than I preferred, it was on-track with the project's needs (see *Weeks 11-12* for completion details).

For the 0223 HVAC Renovation project, the scope was defined and a plan was set for future action. Before leaving in August, I was to work with the current facility engineer for the ES-UI group, and calculate heating/cooling needs of the Tradesman Office area using ASHRAE Excel spreadsheets and information collected on walkthroughs about the facility and tenant needs. The air handling unit required to suit these needs would then be ordered no later than September. My work and assumptions throughout this process would be checked by the facilities engineer for accuracy.

WEEKS 5-6: JUNE 10TH – JUNE 21ST

All preliminary research regarding the CINT Smart Lab was completed by the fifth week of my internship. Moving forward, we had more questions and specific inquiries to make during several walkthroughs of the facility regarding our technical assessment and speaking with tenants. We checked to ensure the drawings matched the actual building due to lack of as-built drawings, and our conversations with tenants allowed us to learn about their research areas and specific needs. The following are several of the important notes made after these walkthroughs:

[1] the laboratories with laser equipment must have a constant temperature (no more than +/- 1 degree) in order for the lasers to remain properly calibrated
[2] tenants use electric chillers for laser equipment, which distorts the thermostat reading due to heat exhausting from the chillers
[3] the lighting for open corridors and hallways were circuited to only two light switches, causing the lights to be left on at all hours of the day
[4] chemical hazards in each laboratory were noted in order to approach industrial hygienists about reduced air changes
[5] cluttered fume hoods and work spaces were observed as high ventilation demand areas
[6] tenants do not have set work hours—the building could be occupied at any hour of the day
[7] large, new, electric chillers were placed outside to service the cooling demands of the building
[8] the office spaces were designed to run at the same air changes per hour as the laboratory space designs (10 ACH) for higene purposes

[9] air handing unit one (AHU-1 or HVA-1 used interchangeably) serviced the laboratories at 100% outside air, while AHU-2 (also called HVA-2) primarily serviced the office spaces. The labs are dependent on infiltration from AHU-2 to properly keep an average of ten ACH, thus deeming the units to be co-dependent
[10] some tenants are open to change while others are hesitant
[11] most of the electric consumption at CINT is from the main water chillers for the facility

On June 13th, I presented the Weekly Smart Lab Presentation to our panel of managers and mentors (see *Appendix A.1*). This presentation took place each week and rotated presenters throughout the student group. The purpose of this presentation was to inform our management and mentors about our progress, to prepare us for final presentations in August, and to share information on our individual projects outside of the Smart Lab. My presentation, specifically, addressed our chosen design areas and brainstorming which occurred during our research phase and my life-cycle cost analysis spreadsheet.

On June 18th, I went on a walkthrough of TA-03-0223 to take inventory and introduce the project to tenants. The facility engineer and I recorded equipment to include with heat load calculations, recorded structural components to include with heat load calculations, physically accessed current air handling units in the attic, and spoke with tenants about comfort and needs. Before climbing to the attic, I took a ladder safety training course which certified me to climb ladders and inspect them for my personal use. This course was held by LANL at their training facility and required voluntary sign up.

WEEKS 7-8: JUNE 24TH – JULY 5TH

After the Smart Lab research phase concluded, our numerical analyses began to decide which design changes were plausible. At this time, I led the HVAC calculations regarding CINT's air handling units. The questions to answer with my analysis was: *Can we separate HVA-1 (labs) and HVA-2 (offices) by sealing the lab doors and preventing infiltration? Could we then save energy by manipulating HVA-2 temperatures, air changes, etc.?*

To solve this problem, I used the ASHRAE 2019 HVAC calculation Excel spreadsheets to find the maximum possible cooling load HVA-1 could experience. This value would then be converted to cubic feet per min (CFM) required to cool the space, and compared to the initial design specifications which defined the capabilities of HVA-1. If this load was within the unit's abilities, and my numbers were checked by a facility engineer for correctness, I would then move on to calculate results of possible manipulation of HVA-2 to save energy. The assumptions made for these calculations included (1) all temperatures held at the LANL design conditions and the initial temperature designs for this building, (2) all laboratory doors were sealed in order to rid of infiltration from HVA-2, and (3) all lighting in laboratories were LED lights, and (4) necessary material properties, such as thermal conductivity or material thicknesses, were extracted from ASHRAE materials and architectural drawings using AutoCAD.

My results found the new maximum, nearly-impossible load on AHU-1 would occur in the summer and require 29,260 CFM for proper cooling (see *Appendix A.2 and A.4*). AHU-1 was rated by its manufacturer to run between an initial operating point of 27,100 CFM and a minimum airflow of 21,600 CFM. Also, according to the specifications, the equipment was designed at a maximum of 31,200 CFM (see *Figure 5*), meaning our changes would be allowable for AHU-1.

Aside from the Smart Lab project, I progressed with the LCCA project by acquiring another pilot study, the TA-16 Fire Station project, and also had a fellow student use my spreadsheet to analyze proposed lighting changes for the CINT Smart Lab. The TA-16 Fire Station assignment tasked me with the analysis of implementing a solar PV array on the roof to determine if it was cost effective to do so. When I received this assignment, I presented my spreadsheet to the project engineer for the fire station and she provided me with positive feedback regarding the purpose of my tool. For the lighting changes to CINT, I asked my co-worker to complete the analysis without asking me questions, and then we would go over it together. He reported it to be user friendly, using about an hour of his time, and that he was confident he would be faster the next time it was used (see *Appendix B.2*). This student had no previous knowledge of life cycle cost analysis.

WEEKS 9-10: JULY 8TH – JULY 19TH

By July 11th, I had completed the heat load calculations for the second air handling unit (AHU-2 or HAV-2) for CINT in the same fashion as I did previously for AHU-1. These calculations became a major savings component for the Smart Lab project because they allowed us to quantify our changes and results. For the AHU-2 calculations to be completed, I assumed (1) all temperatures held at the LANL design conditions and the initial temperature designs for this building, (2) all laboratory doors were sealed in order to rid of infiltration from HVA-2, (3) all lighting elements were LED lights, and (4) necessary material properties, such as thermal conductivity or material thicknesses, were accurately represented on ASHRAE materials and architectural drawings using AutoCAD.

My results found the new maximum load on AHU-2 would occur in the summer and require 12,360 CFM for proper cooling (see *Appendix A.3 and A.4*) at five air changes per hour (ACH) in all office/corridor/hall spaces. AHU-2 was rated by its manufacturer to run between an initial operating point of 25,815 CFM and a minimum airflow of 12,300 CFM. Also, according to the specifications, the equipment was designed at a maximum of 29,690 CFM (see *Figure 5*), meaning our changes would be allowable for AHU-2 and bring it closer to the minimum airflow allowance rather than close to the maximum allowance. With my calculations confirmed by a facility engineer with the ES-UI group, I moved forward to manipulate HVA-2 temperatures and air change setpoints to generate projected savings.

Completing the engineering analysis for HVAC needs of CINT taught me several new concepts I can use for the rest of my career: [1] the difference between electric and thermal energy, each one having different burdening costs to the organization; the cooling needs for the CINT facility were met with electric energy (electrically-powered water chillers), and the heating needs were met with thermal energy (steam from the steam plant generated by natural gas), [2] when manipulating HVAC systems, it is important to understand changes such as fan speeds, pressure differentials, and direction of exhaust draft, [3] laboratory safety requirements are strict and costly to test/adjust/balance, and [4] building automation systems (BAS) are very helpful to make small changes with large results.

Also during this time, the Smart Lab team finalized the proposed and plausible design solutions, completed several supporting project management documents, began designing the Student Symposium poster, had several meetings with industrial hygienists, and had a walkthrough of CINT with the design team that would be taking over our work after the summer in through.

Aside from the Smart Lab project, I completed the heat load calculations for the TA-03-0223 Tradesman Offices (see *Appendix C.1 and C.2*), concluding that a ten-ton air handing unit would be sufficient to service the spaces in that building. Next steps for this project were determined as ordering the unit from Trane, meeting with a civil engineer to build the exterior landing for beneath the unit behind the building, and shadowing the facility engineer as he drafted ducting models and made decisions regarding the new ventilation design.

For the pilot LCCA cases, I contacted estimators and project personnel for specific information regarding line-items on my spreadsheet.

WEEKS 11-12: JULY 22ND – AUGUST 2ND

As our group presentation dates were approaching, my tasks for the Smart Lab group included evaluating energy usage and savings, life-cycle cost analysis for the CINT Smart Lab, checking my calculations with a facility engineer, leading several team meetings to be sure we were all informed and busy, presenting the Weekly Smart Lab Presentation, and submitting the student symposium poster for approval and printing.

The energy usage and savings evaluations were done by manipulating air changes, temperature, fan speeds, and energy recovery in the CINT facility. Thermal energy costs were quantified by working backward from the CINT facility, through the underground pipe loss, through the steam plant, and to the amount of natural gas used (see *Appendix A.6*). The electric savings were calculated using the electric meter connected to CINT and the projected needs of the Smart Lab design. Each component of the design was analyzed individually to determine specific electric and thermal energy savings. The total CINT Smart Lab used the sum of these savings. See *Figure 6* below for the list of total calculated energy and cost savings:

Current CINT Energy

- $166,000
- 19,700 MMBTU

Smart Lab Energy Savings

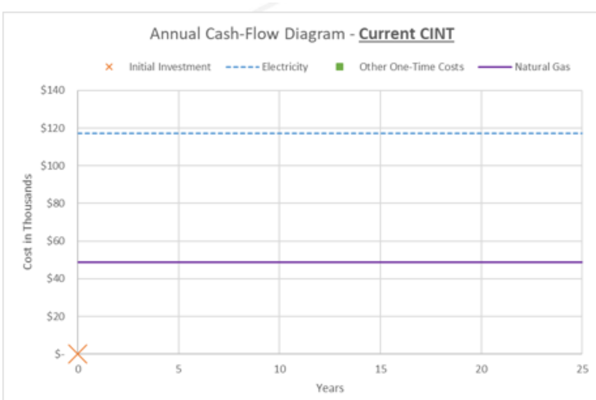
- 8,554 MMBTU
- 44%

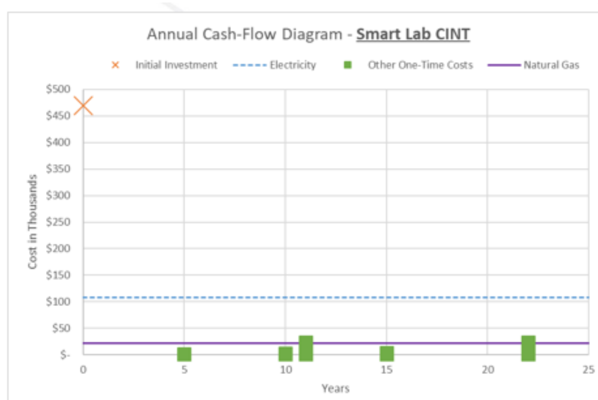
Smart Lab Cost Savings

- $36,800
- 22%

Figure 6: Calculated Smart Lab Annual Energy and Cost Savings

For the life-cycle cost analysis, I used my LCCA Excel Spreadsheet to calculate a ten-year discounted payback period. This period was based upon the comparison of the present annual cost of CINT and the cost of the CINT Smart Lab over the next 25 years (see *Appendix A.7*). All rates for annual, single, fuel, and non-fuel costs were discounted as government costs and can be found using the annual supplemental discount rates for NIST Handbook 135 (See *Figure 1*). The resulting payback, cash flows, and present values from use of my spreadsheet are presented below in *Figure 7*:





Current CINT Present Value (25 years): $186,000.00

Smart Lab Present Value (25 years): $633,300.00

Discounted Payback Period: 10 Years

Figure 7: CINT Life-Cycle Cost Analysis Results: Current CINT vs. Smart Lab CINT from 2019-2044

On July 25th, I gave the Smart Lab Weekly Team Presentation where I shared updates on concrete design focuses, numerical savings estimates, current scheduling, accomplishments, barriers, and also my individual projects (see *Appendix A.5*).

Aside from the Smart Lab project, I completed the TA-15 Office Trailers LCCA and presented my results to the Project Engineer. I also received the estimate from the TA-16 Fire Station estimator, who then met with me and explained the items listed which I could use in my LCCA Excel sheet.

For three hours I walked through TA-03-0030 as preparation for my next project titled “SM-30 HVAC Study”. During this walkthrough, the facility engineer and I evaluated the old drawings in comparison to the current facility, interviewed tenants, and assessed occupancy numbers and technology used. This information prepared me for heat load calculations and helped me understand the facility’s problems to solve.

WEEKS 13-14: AUGUST 5TH – AUGUST 15TH

During the last two weeks of my summer internship, I delivered several presentations, completed the TA-16 Fire Station LCCA, drafted a renovation proposal using data from my SM-30 heat load calculations and walkthroughs, as well as submitted the final design package for the CINT Smart Lab to the Capital Projects Division (ALDCP) at LANL.

On August 6th, the Smart Lab Team was judged and presented in the Engineering category at the LANL Student Symposium all-day event. This was an opportunity to present what we had done, practice explaining our project, and personally present to prospective employers we invited to come. I walked away from this day feeling very confident in the engineering skills I’d gained during the summer (including presentation skills) and pleased with the interest expressed in me by prospective employers. See *Appendix A.8* for the poster visual we presented, and see *Figure 8* below for a photograph from the LANL 2019 Summer Student Symposium:

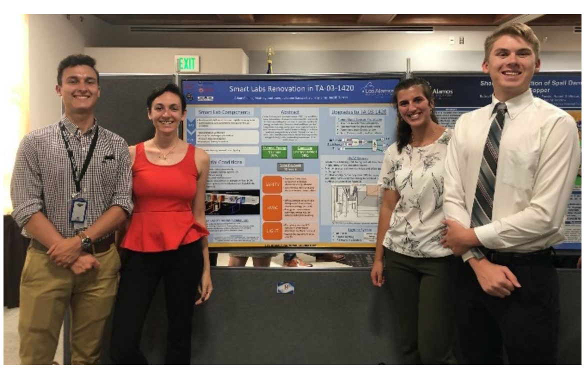


Figure 8: LANL 2019 Summer Student Symposium, CINT Smart Lab Team

On the 7th of August, the Smart Lab group presented to all mentors, supervisors, subject matter experts, interested personnel, and division leaders of LANL Capital Projects (ALDCP) and Engineering Services Utilities and Institutional Facilities (ES-UI). This presentation was an in-depth explanation of our project, processes and conclusions for further progression of the CINT Smart Lab, as well as a brief presentation of our individual projects. See *Appendix A.9* for this final team presentation.

On August 8th, I presented my life-cycle cost analysis Excel tool to nearly thirty Project Engineers and Program Managers. This presentation style allowed for open discussion as I went through the example of the CINT Smart Lab LCCA and explained how to fill in each step and what line of thought to have while doing so. I received very positive feedback for the rest of the week and felt very happy with my performance and ability for technical discussion. I gave the same presentation to a smaller group of engineers the next day after their Project Engineer asked me to come in. See *Appendix B.3* for the finished and distributed template of the LCCA tool, and see *Appendix B.4* for the presentation on how to use the tool.

EVALUATION OF INTERNSHIP EXPERIENCE

Over the course of the summer of 2019, I learned many valuable skills regarding technical engineering concepts, interpersonal skills, and how I personally learn best. I was fortunate to have a team of mentors and supervisors who pushed me to complete many projects, expose me to as much as possible, answer questions as needed, and check my work for correctness. By the end of the summer, I learned enough to qualify for all necessary and desired requirements for a “Facility Engineer 1” position, which I was encouraged to apply for and return to after graduation.

I exercised concepts learned at Montana State University regarding thermodynamics, networking skills learned at the Career Fair, and presentation skills practiced in class. New concepts I learned from this internship included how to calculate heating/cooling loads based upon ASHRAE methods, thermal conductivity of materials in a facility, lifetime expectancy of equipment, energy costs, general facility efficiency, laboratory ventilation needs, office ventilation needs, AutoCAD software for drawing and HVAC use, use of building automation systems, meeting with SMEs for information, how to gather information from walkthroughs and interviews, life-cycle cost analysis, how to comply with local/state/ and federal facility requirements, how/who to network, and how to have causal interviews. I also learned I need to improve my skills regarding heat transfer, vibrations, use of AutoCAD, and learning more specific ASHRAE concepts.

Aside from facility engineering, I also gained knowledge through networking and laboratory tours about biomedical engineering, bioengineering, microfluidics, and magnetism. I also participated in two specific trainings, the first regarding ladder safety and the second regarding working in a team with different personalities. These trainings were valuable because I will apply fried safety concepts and teamwork concepts for the reset of my career as an engineer.

SUGGESTIONS FOR IMPROVING INTERNSHIP EXPERIENCE

Regarding EMEC 498 at Montana State University, electronic templates and documents (rather than printed and scanned documents) would improve time efficiency and visual clarity regarding initial approval of the course with company personnel, as well as for performance review purposes. For the final intern performance review, I replicated the form provided to become a Word Document and PDF. This allowed me to address my supervisor groups specifically and enhanced their experience and time efficiency as they filled out the review.

Regarding my time as an intern with LANL, I struggled with travel between work sites without my own vehicle. Housing was also an issue within the small town of Los Alamos due to the town being developed on national forest land. I also recall frustrated moments with slow approval of software installs which, in turn, delayed my productivity on projects.

APPENDICES

Appendix A: CINT Smart Lab

A.1 Weekly Team Presentation (6/13/19)

A.2 AHU-1 Heat Load Calculations (ASHRAE)

A.3 AHU-2 Heat Load Calculations (ASHRAE)

A.4 AHU Heat Load Calculation Factors (ASHRAE)

A.5 Weekly Team Presentation (7/24/19)

A.6 Energy Calculations and Conclusions

A.7 Total Smart LCCA

A.8 Student Symposium Poster

A.9 Final Team Presentation

Appendix B: Life-Cycle Cost Analysis (LCCA)

B.1 Initial LCCA Workbook Example

B.2 Test Study: CINT Smart Lab Lighting

B.3 Final LCCA Template

B.4 Final LCCA Presentation

Appendix C: TA-03-0223 HVAC Calculations

C.1 TA-03-0223 Heat Load Calculations /Assumptions (ASHRAE)

C.2 TA-03-0223 Heat Load Calculation Factors (ASHRAE)

APPENDIX A: CINT SMART LAB

A.1 WEEKLY TEAM PRESENTATION (6/13/19)

Los Alamos
NATIONAL LABORATORY
EST. 1943

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ALDCP Student Team Weekly Briefing

Week 2 Briefing
Matney Juntunen
June 13th, 2019

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Managed by Triad National Security, LLC for the U.S. Department of Energy's NNSA

LA-UR-19-25711

Hazard Classifications:

<u>Health:</u>

- Toxicity
- Sensitization
- Carcinogenic
- Mutagenic

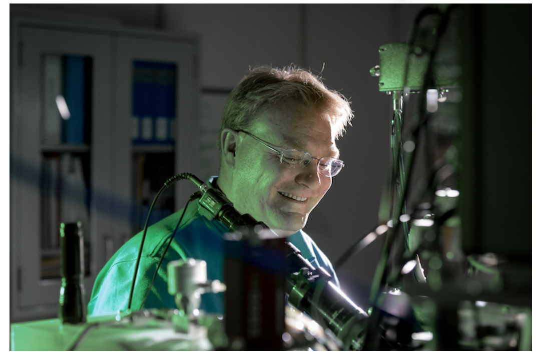
<u>Physical:</u>

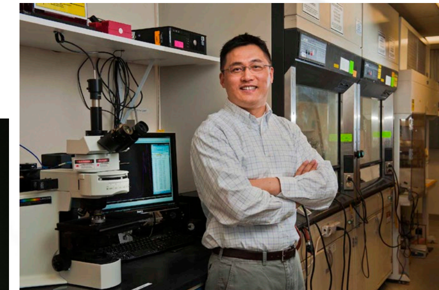
- Flammable/Explosive
- Reactive
- Oxidizer
- Corrosive
- Irritant
- Pressurized gas

Understanding hazards prevents employees from injury/illness due to exposure.

What is a Smart Lab?

	SMART LAB KEY COMPONENTS
1	Fundamental platform of dynamic, digital control systems
2	Demand-based ventilation
3	Exhaust fan discharge velocity optimization
4	Pressure drop optimization
5	Fume hood flow optimization
6	Low power density, demand based lighting
7	Commissioning with automated cross platform fault detection





Better Buildings® U.S. DEPARTMENT OF ENERGY

Smart Labs aims to reduce energy demands for laboratories.

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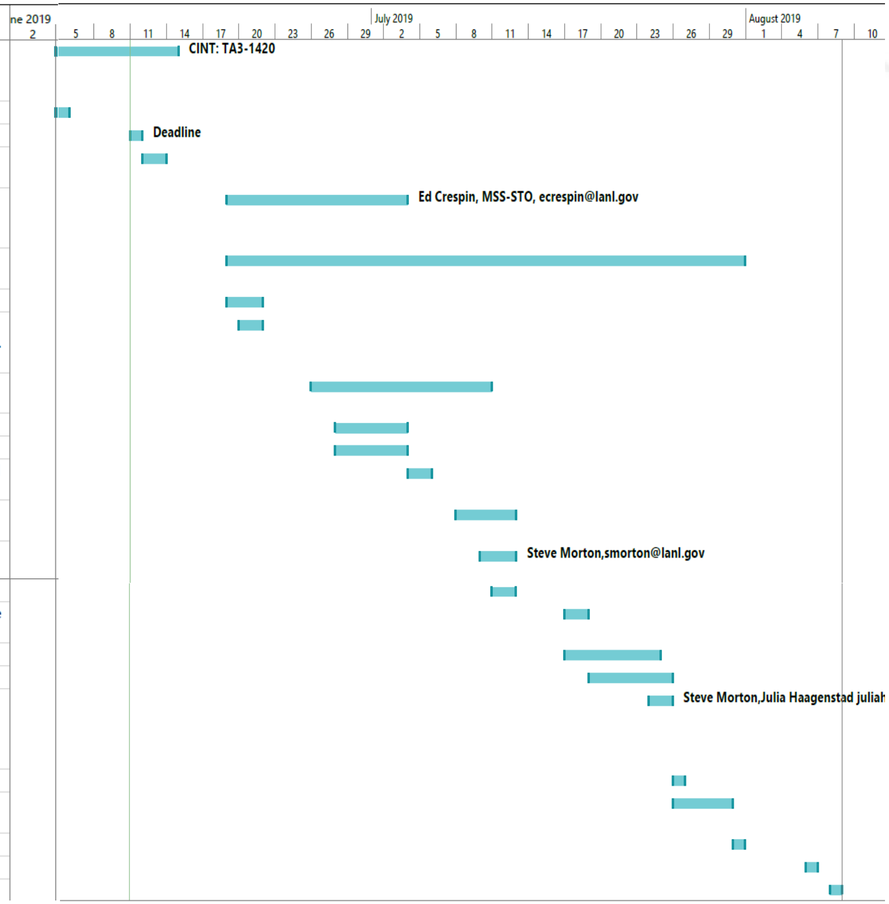
- Identify/Define problems to be solved in TA-03-1420 (CINT)
- Propose renovations regarding key Smart Lab components
- Perform life-cycle cost analysis for the proposed renovations
- Learn and use Project Management roles/skills

We are aiding the implementation of the Smart Lab initiative at LANL.

Gantt Chart

ID		Task Mode	Task Name	Duration	Start	Finish	Predecessors	Resource Names	Notes
1			Preliminary Research/Team Roles	8 days	Wed 6/5/19	Fri 6/14/19		CINT: TA3-1420	Study Smart Labs, CINT, and meet with SMEs.
3			PID Form	1 day	Wed 6/5/19	Wed 6/5/19			350-100-FM01
24			Sign Up -Symposium	1 day	Tue 6/11/19	Tue 6/11/19		Deadline	
2			Draft Mission Needs Statement	2 days	Wed 6/12/19	Thu 6/13/19			350-105-FM01
7			Building Walkthroughs	11 days	Wed 6/19/19	Wed 7/3/19		Ed Crespin, MSS-STO, ecrespin@lanl.gov	Check inventory, floor plan, HVAC, BAS.
8			Components of Poster	31 days	Wed 6/19/19	Wed 7/31/19			
13			Numerical Analysis	3 days	Wed 6/19/19	Fri 6/21/19			
9			Create/Send Out Survey for Tenants	2 days	Thu 6/20/19	Fri 6/21/19			Ask about purpose, facility, and workers.
10			Design Solutions for CINT	11 days	Wed 6/26/19	Wed 7/10/19			Draft drawings and cost
5			RCD,PRID	4 days	Fri 6/28/19	Wed 7/3/19			
6			RPA	4 days	Fri 6/28/19	Wed 7/3/19			
11			1st Life-Cycle Cost Analysis	2 days	Thu 7/4/19	Fri 7/5/19			Matney's LCCA Excel calculator.
12			Meet with SMEs (again)	5 days	Mon 7/8/19	Fri 7/12/19			Discuss design concepts
4			Funding-Preparation of Cost Esimate	3 days	Wed 7/10/19	Fri 7/12/19		Steve Morton,smorton@lanl.	Class 4 or 5
15			Final LCCA	2 days	Thu 7/11/19	Fri 7/12/19			
14			TAB	2 days	Wed 7/17/19	Thu 7/18/19			Test, Adjust, Balance
16			Finalize Design	6 days	Wed 7/17/19	Wed 7/24/19			
17			Finalize Drawings	5 days	Fri 7/19/19	Thu 7/25/19			
18			Contruction Plan	2 days	Wed 7/24/19	Thu 7/25/19		Steve Morton,Julia Haagenstad juliah@lanl.gov	Prioritization/Gantt
19			Project Finished	1 day	Fri 7/26/19	Fri 7/26/19			
20			Create Poster and Presentation	3 days	Fri 7/26/19	Tue 7/30/19			
21			Print Poster	1 day	Wed 7/31/19	Wed 7/31/19			
22			Student Symposium	1 day	Tue 8/6/19	Tue 8/6/19			
23			Final Presentation	1 day	Thu 8/8/19	Thu 8/8/19			?????



The Smart Lab design for CINT will be completed by July 26th, 2019

Accomplishments and Barriers:

- General research
- Six SME meetings
- Gantt chart
- Team roles
- PID
- Draft of tenant questions
- Draft Mission Needs Statement

BARRIERS:

- Response from CINT to schedule group tour
- Transportation

Progress continues ahead of schedule toward our scope of work.

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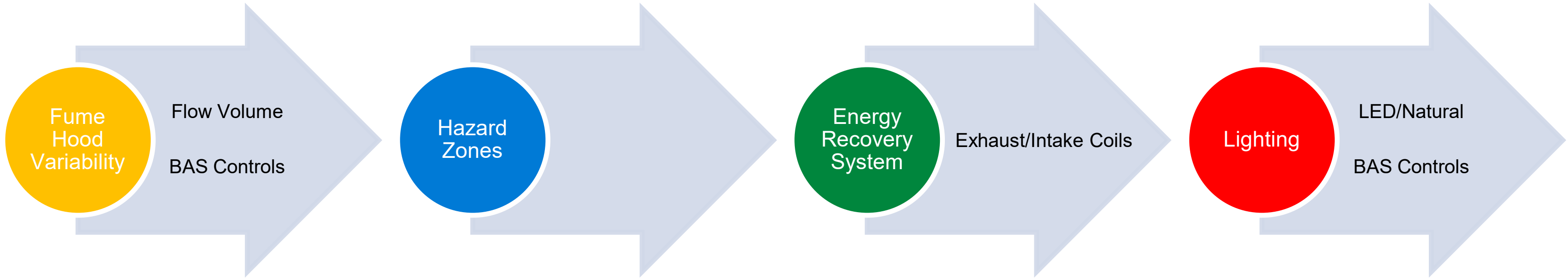
Group Brainstorming: Current Design Subjects



We must understand the purpose of CINT to successfully design for it.

Plan of the Week (POW):

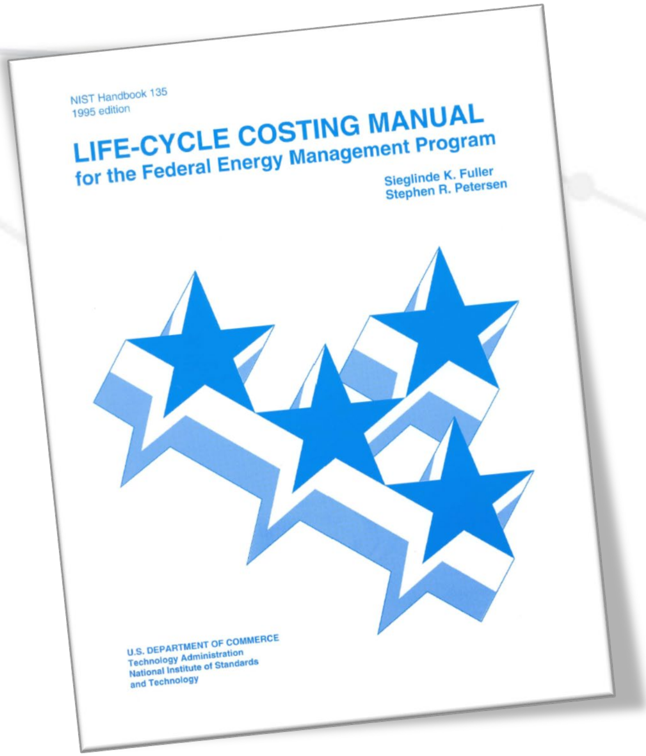
ACTION ITEMS
• Gather data from tenants (tour)
• Compare facility features with current documents (tour)
• Outline Student Symposium poster
• Begin numerical analyses for top ideas
• Student Symposium application (today)

Individual Project:

Life-Cycle Cost Analysis (LCCA) Calculator

Why a calculator?

- LANL engineers struggling to commit time to thorough LCCA
- Required by Engineering Standards Manual STD-342-100
- Process outlined in the NIST Handbook 135 (1995), with annual supplemental rates



LANL Engineers need an easier way to analyze LCC.

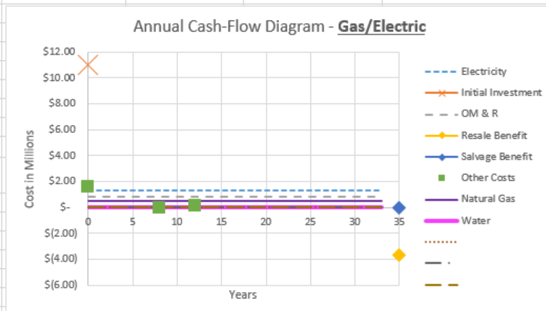
Calculator Example:

Cost of Gas vs. Electric LCC Analysis Calculator - See Appendix C in NIST Handbook 135 for Guidance

PROJECT IDENTIFICATION		Notes
Project Name:	Fun Project Yay	
Fiscal year:	1995	
Location:	LANL	DoE region
Base Date (BD):	5/3/2019	MM/DD/YYYY
Service Date (SD):	8/25/2022	MM/DD/YYYY
Design Feature to be Evaluated:	Energy source	
List Constraints:		Attach page if needed
Energy/Water Conservation Study? (FEMP)	Yes	(yes or no)
OMB A-94?	No	Office of Management and Budget circular?
BASE CASE AND ALTERNATIVES		
Name and describe base case and alternatives to be analyzed:		
Base case is 100% electric energy, as preferred by management.		
GENERAL INFORMATION:		
Name of Analyst:	Matney Juntunen	
Phone Number:	406-203-8951	
Z-Number:	341830	
Date of Study Completion:	6/12/2019	MM/DD/YYYY
KEY DATES		Notes
Years of Life:	35	Quantity (commonly 35 years)
BD:	5/3/2019	
SD:	8/25/2022	
End of Study:	6/12/2019	

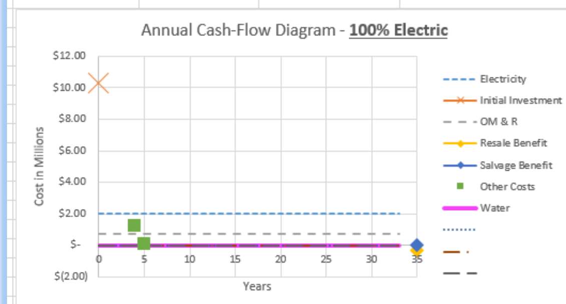
CASH FLOWS (IN MILLIONS) FOR GAS/ELECTRIC

CATEGORY	YEAR # IN LIFETIME	COST PER YEAR	Notes
Initial investment:	0	$ 11.00	
Total Electricity:	all	$ 1.30	(Usually $0.08 per kW/h)
OM & R:	all	$ 0.80	
Total Natural Gas:	all	$ 0.50	(Usually $3.5 per million Btu)
Water:	all	$ 0.00000170	
	all		
	all		
	all		
Gas Line Extension	0	$ 1.60	
Fan Replacement	12	$ 0.16	Other **One-Time** Costs
Economizer Install	8	$ 0.0125	(replacements, disposal, etc.)
Resale value:	35	$ 3.70	End of Life Expectancy
Salvage Value:	35	$ 0.03	End of Life Expectancy
Total Cost of Lifetime (Millions):		**$ 474.05**	



CASH FLOWS (IN MILLIONS) FOR 100% Electric

CATEGORY	YEAR # IN LIFETIME	COST	Notes
Initial investment:	0	$ 10.30	
Total Electricity:	all	$ 2.00	(Usually $0.08 per kW/h)
OM & R:	all	$ 0.70	
Water	all	$ 0.0000017	
	all		
	all		
	all		
Fan Replacement	12	$ 1.20	Other **One-Time** Costs
Economizer Install	4	$ 0.10	(replacements, disposal, etc.)
Resale value:	35	$ 0.35	End of Life Expectancy
Salve Value:	35	$ 0.03	End of Life Expectancy
Total Cost of Lifetime (Millions):		**$ 455.93**	



User entries are coded for processing throughout the workbook.

Calculator Example Continued:

Specify Gas/Electric Investment Costs: (in Millions)						
CATEGORY	AMOUNT	Notes	DISCOUNT FACTOR	Notes	FACTOR TABLE NO.	PRESENT VALUE
Initial Investment:	$ 11.00		1	(Inflation	-	$ 11.00
Resale:	$ (3.70)		0.554	included in	A-1	$ (2.05)
Salvage:	$ (0.03)			NIST		$ -
Fan Replacement	$ 1.25	See	0.701	Handbook	A-1	$ 0.88
Ecomomizer Install	$ 0.01	previous	0.692	135 Annual		$ 0.01
		sheet		Suppliment		$ -
		values and		discount		$ -
		parts		factors)		$ -
						$ -
				Total Investment-Related Costs:		$ 9.84

Specify Gas/Electric Operation-Related Costs: (in Millions)						
CATEGORY	AMOUNT	Notes	DISCOUNT FACTOR	Notes	FACTOR TABLE NO.	PRESENT VALUE
Total Electricity:	$ 1.30		15.13	(Inflation	Ba-3	$ 19.67
OM & R:	$ 0.80		14.88	included in	A-2	$ 11.90
Total Natural Gas:	$ 0.50			NIST		$ -
Water:	$ 0.00	See		Handbook		$ -
		previous		135 Annual		$ -
		sheet		Suppliment		$ -
		values and		discount		$ -
		parts		factors)		$ -
						$ -
				Total Operation-Related Costs:		$ 31.57
Total Gas/Electric Present Value Life Cycle Costs:						$ 41.41

Calculate Savings-to-Investment Ratio:

Operational-Related Costs:	Lower-First-Cost Option	Higher-First-Cost Option	Savings
Total Energy:	$ 30.26	$ 19.67	$ 10.59
OM & R:	$ 10.42	$ 11.90	$ (1.49)
Water:	$ -	$ -	$ -
Sum of Other Costs:	$ -	$ -	$ -
Total Op. Savings (in Millions):			**$ 9.10**

Investment-Related Costs:	Higher-First-Cost Option	Lower-First-Cost Option	Savings
Initial Investment:	$ 11.00	$ 10.30	$ 0.70
Resale+Salvage:	$ (2.05)	$ (0.22)	$ (1.83)
Sum of Other Costs:	$ 0.88	$ 0.91	$ (0.03)
Total Additional Investment (in Millions):			**$ (1.15)**
Savings-to-Investments Ratio (SIR):			**-7.8903**

Discount Payback Period Result:

First Positive Savings:	$ 0.462
PAYBACK PERIOD:	2
FISCAL YEAR OF DISCOUNT PAYBACK:	2024

Calculations are visible to the user, but the main objectives are clearly outlined.

Accomplishments and Barriers:

- First draft demonstrating the example provided in NIST Handbook 135
- Printer-friendly
- Assignment for TA-15 office trailers
- Assignment for TA-16 fire station

BARRIERS:

- Response time from sources regarding line-item costs
- First “real” run

The purpose of these actions is to assist LANL with informed investments.

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Plan of the Week (POW)

STEPS OF ACTION
• Receive cost estimates from current projects
• Use similar past projects to extract missing values
• Use line-item information to run LCCA projects

Collaboration with project personnel allows the LCCA to occur.

Questions?

A.2 AHU-1 HEAT LOAD CALCULATIONS (ASHRAE)

HVAC Load Calculations - CINT Smart Lab - Air Handling Unit 1

Based on 1997 ASHRAE Handbook CLTD/SCL/CLF Method

Project:	HVU1 Heat Calcs - All Labs Sealed, All LED Lights
Project No.:	
Date:	June 19, 2019
Calcs By:	Matney Juntunen
Block or Terminal Loads	Block

Summer Dry bulb (F):	89
Summer Relative Humidity:	30%
Summer design temp indoors:	75
Summer Delta Enthalpy:	4.22
Winter Dry bulb (F):	5
Winter Relative Humidity:	30%
Winter design temp indoors:	72
Winter Delta Enthalpy:	22.52

INPUT

General Data

Project Location:	TA-03-1420	
Project Latitude:		deg. N.
Weather Data Source	2017 ASHRAE Handbook of Fundamentals, Chapter 14	
Summer Criteria	1.0	% Occurance
Winter Criteria	99.6	% Occurance
Safety Factor - Cooling	0	%
Safety Factor - Heating	25	%

Total HVA-1 Cooling Needs:	555,790 BTU/Hr 29,267.50 CFM
Total HVA-1 Heating Needs:	-25,350 BTU/Hr (250.15) CFM
HAV1 Spring/Fall:	290,570 Btu/hr 14,759 CFM

5587 CFMs and 106,100 BTUs saved per hour without electric chillers

Total room volumes:	92,350 sf

System Description	HVA-1 Heat Load Calculations	
Summer Outside Design Temerature	89	degF
Inside Summer Design Temperature	75	degF (Default value)
Summer SA Temperature	55	degF
Winter Outside Design Temerature	5	degF
Inside Winter Design Temperature	72	degF (Default value)
Max. Winter SA Temperature	95	degF
Min. SA Airflow Percentage	30	%
Infiltration - Air Change Method	0.25	Air Changes/Hr
Infiltration - Air Leakage Method	0.05	CFM/sf of Wall/Glass surface
People - Sensible Heat	250	BTU/Hr/ Person
People - Latent Heat	160	BTU/Hr/ Person

Room Data	**Room Description**	Laser with 1 Chill Cabinet	Laser with 1 Chill Cabinet	Office	Chem/Laser: 1 Hood, 1 Vac Cabinet	Chem/Laser: 1 Hood, 1 Vac Cabinet	Laser with 1 Vac Cabinet	Laser: 1 Vac Cabinet, Humidifier	Laser	Heavy Laser + 1 Vacuum Cabinet
Room No.:		1201	1203	1217	1221	1225	1202	1206	1208	1210
Room Name:										
Peak Cooling Month										
Peak Cooling Time										
Summer Inside Temp (^oF)		70	70	70	70	70	70	70	70	70
Winter Inside Temp (^oF)		66	66	66	66	66	66	66	66	66
Safety Factor - Summer (%)		0	0	0	0	0	0	0	0	0
Safety Factor - Winter (%)		25	25	25	25	25	25	25	25	25
Room Width (ft)										
Room Length (ft)										
Room Height (ft)		10	10	10	10	10	10	10	10	10
Room Floor Area (sf)	5,662	1,315	642	830	544	530	517	517	250	517
Room Volume (ft^3)	56,620	13,150	6,420	8,300	5,440	5,300	5,170	5,170	2,500	5,170
Ceiling/Parition 1 - Room Name										
Ceiling/Patition 1 Area (sf)	0									
Parition Summer Temp (^oF)										
Parition Winter Temp (^oF)										
Parition 2 - Room Name										
Patition 2 Area (sf)	0									
Parition 2 Summer Temp (^oF)										
Parition 2 Winter Temp (^oF)										
Parition 3 - Room Name										
Patition 3 Area (sf)	0									
Parition 3 Summer Temp (^oF)										
Parition 3 Winter Temp (^oF)										
Roof Net Area (sf)	0									
Skylight Area (sf)	0									
Exposed Floor Area:	0									
Slab Edge Length (ft)	0									
Below Gr Wall Area (sf)	0									
Below Gr. Floor Area (sf)	0									
Wall 1 Direction (N, NE..)										
Wall 1 Net Area (sf)	0									
Fenestration 1 Area (sf)	0									
Fenestration 1 Infilration (cfm)	0									
Door 1 Area (sf)	0									
Door 1 Infiltration (cfm)	0									
Wall 2 Direction (N, NE..)										
Wall 2 Net Area (sf)	0									
Fenestration 2 Area (sf)	0									

Room No.:		1201	1203	1217	1221	1225	1202	1206	1208	1210
Room Name:										
Fenestration 2 Infilration (cfm)	0									
Door 2 Area (sf)	0									
Door 2 Infiltration (cfm)	0									
Wall 3 Direction (N, NE..)										
Wall 3 Net Area (sf)	0									
Fenestration 3 Area (sf)	0									
Fenestration 3 Infilration (cfm)	0									
Door 3 Area (sf)	0									
Door 3 Infiltration (cfm)	0									
Wall 4 Direction (N, NE..)										
Wall 4 Net Area (sf)	0									
Fenestration 4 Area (sf)	0									
Fenestration 4 Infilration (cfm)	0									
Door 4 Area (sf)	0									
Door 4 Infiltration (cfm)	0									
People Type 1 - BTUH/Per. - Sensible		275	275	275	275	275	275	275	275	275
People Type 1 - BTUH/Per. - latent		475	475	475	475	475	475	475	475	475
No. of People - Type 1		3	2	2	2	2	2	2	2	2
People/1000 sf - Type 1										
People Type 2 - BTUH/Per. - Sensible										
People Type 2 - BTUH/Per. - latent										
No. of People - Type 2										
People/1000 sf - Type 2										
Total No. of People	19	3	2	2	2	2	2	2	2	2
Lights (Watts) -Type 1		1368	684	285	513	456	456	228	285	228
LIghts (Watts/sf) - Type 1		1.0	1.1	0.3	0.9	0.9	0.9	0.4	1.1	0.4
% of Lights to Space (0-100%) - Type 1		50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%
Lights (Watts) - Type 2		114.0	456.0	456.0	171.0	171.0		456.0		456.0
LIghts (Watts/sf) - Type 2		0.1	0.7	0.5	0.3	0.3	0.0	0.9	0.0	0.9
% of Lights to Space (0-100%) - Type 2		50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%
Tot. Lighting Watts to Space	7,191	1482	1236	764	653	597	456	859	285	859
Tot.Lighting Watts to Plenum	5,415	1482	681	848	474	466	259	540	125	540
Equipment 1 (watts) - **2 Desktops**		400	400	400	400	400	400	400	400	400
Equipment 1 (BTU/H Sens.)										
Equipment 1 (BTU/H Lat.)										
Equipment 2 (watts) - **Exhaust Cabinet**										
Equipment 2 (BTU/H Sens.)		200	200	200	200	200	200	200		200
Equipment 2 (BTU/H Lat.)										
Equipment 3 (watts) - **Hoods, Chillers, Lasers**		12349.52	12349.52	12349.52	1991.86	1991.86	1991.86	1991.86	12349.52	12349.52
Equipment 3 (BTU/H Sens.) - Chiller Info				36000						36000
Equipment 3 (BTU/H Lat.)										
Total Equip.(BTU/H Sens.)	323,604	43675.8709	43675.8709	79675.8709	8356.237242	8356.23724	8356.237242	8356.237242	43475.8709	79675.8709
Total Equip.(BTU/H Lat.)	0	0	0	0	0	0	0	0	0	0

Summer U-factor Data

Roof									
Skylight									
Exposed Floor									
Wall 1 - Gypsum									
Wall 2									
Wall 3									
Wall 4									
Fenestration 1									
Fenestration 2									
Fenestration 3									
Fenestration 4									
Door 1 - wood									
Door 2									
Door 3									
Door 4									
Ceiling/Partition 1									
Partition 2									
Partition 3									

Winter U-factor Data

Roof - N/A									
Skylight - N/A									
Exposed Floor	0.81	0.81	0.13098318	0.130983182	0.13098318	0.72	0.72	0.72	0.72
Slab Edge (BTU/Hr-F-LF) - N/A									
Below Gr. Walls - N/A (BTU/Hr-F-SF)									
Below Gr. Floors - N/A (BTU/H-SF)									
Wall 1									
Wall 2									
Wall 3									

Room No.:	1201	1203	1217	1221	1225	1202	1206	1208	1210
Room Name:									
Wall 4									
Fenestration 1									
Fenestration 2									
Fenestration 3									
Fenestration 4									
Door 1									
Door 2									
Door 3									
Door 4									
Ceiling/Partition 1									
Partition 2									
Partition 3									

CLTD (Cooling Load Temperature Difference) Values

Roof									
Wall 1									
Wall 2									
Wall 3									
Wall 4									
Fenestration 1									
Fenestration 2									
Fenestration 3									
Fenestration 4									
Door 1									
Door 2									
Door 3									
Door 4									

SC (Solar Coefficient glass) x IAC (shading) Values

Skylight									
Fenestration 1									
Fenestration 2									
Fenestration 3									
Fenestration 4									

SCF (Solar Cooling Load Factor) Values

Skylight									
Fenestration 1									
Fenestration 2									
Fenestration 3									
Fenestration 4									

CLF (Cooling Load Factor) Values

People - Type 1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
People - Type 2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Lights - Type 1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Lights - Type 2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Equipment 1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Equipment 2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Equipment 3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

F_U Use Factors

People - Type 1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
People - Type 2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Lights - Type 1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Lights - Type 2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Equipment 1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Equipment 2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Equipment 3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

OUTPUT

Cooling Load (Summer - Sensible)

	System Totals									
Roof	0	0	0	0	0	0	0	0	0	0
Skylight - Transmission	0	0	0	0	0	0	0	0	0	0
Skylight - Solar	0	0	0	0	0	0	0	0	0	0
Exposed Floor	0	0	0	0	0	0	0	0	0	0
Walls	0	0	0	0	0	0	0	0	0	0
Fenestration - Transmission	0	0	0	0	0	0	0	0	0	0
Fenestration - Solar	0	0	0	0	0	0	0	0	0	0
Doors	0	0	0	0	0	0	0	0	0	0
Ceiling/Parition 1	0	0	0	0	0	0	0	0	0	0
Other Paritions	0	0	0	0	0	0	0	0	0	0
People	5,225	825	550	550	550	550	550	550	550	550

Room No.:		1201	1203	1217	1221	1225	1202	1206	1208	1210
Room Name:										
Lights	23,130	5,054	3,887	2,527	2,332	2,138	1,555	2,332	972	2,332
Equipment	323,604	43,676	43,676	79,676	8,356	8,356	8,356	8,356	43,476	79,676
Total Heat Load (BTU/Hr)	351,959	49,554	48,113	82,753	11,239	11,044	10,461	11,239	44,998	82,558
Load with Safety Factor	351,959	49,554	48,113	82,753	11,239	11,044	10,461	11,239	44,998	82,558
BTU/Hr/SF		38	75	100	21	21	20	22	180	160
Max cfm	21,730	3,060	2,970	5,110	690	680	650	690	2,780	5,100
Min cfm	6,520	920	890	1,530	210	200	200	210	830	1,530
Max cfm/sf	3.8	2.3	4.6	6.2	1.3	1.3	1.3	1.3	11.1	9.9
Min cfm/sf	1.2	0.7	1.4	1.8	0.4	0.4	0.4	0.4	3.3	3.0

Cooling Load (Summer - Latent)

People	9,025	1,425	950	950	950	950	950	950	950	950
Equipment	0	0	0	0	0	0	0	0	0	0
Total	9,025	1,425	950	950	950	950	950	950	950	950

Heat Loss (Winter)

	System Totals									
Roof	0	0	0	0	0	0	0	0	0	0
Skylight	0	0	0	0	0	0	0	0	0	0
Exposed Floor	0	0	0	0	0	0	0	0	0	0
Slab Edge	0	0	0	0	0	0	0	0	0	0
Below Gr Walls	0	0	0	0	0	0	0	0	0	0
Below Gr Floor	0	0	0	0	0	0	0	0	0	0
Walls	0	0	0	0	0	0	0	0	0	0
Fenestration	0	0	0	0	0	0	0	0	0	0
Doors	0	0	0	0	0	0	0	0	0	0
Ceiling /Partition 1	0	0	0	0	0	0	0	0	0	0
Other Partitions	0	0	0	0	0	0	0	0	0	0
Total Infiltration CFM	236	55	27	35	23	22	22	22	10	22
Infiltration BTU/Hr	-15,542	-3,610	-1,762	-2,278	-1,493	-1,455	-1,419	-1,419	-686	-1,419
Total Heat Loss (BTU/Hr)	-15,542	-3,610	-1,762	-2,278	-1,493	-1,455	-1,419	-1,419	-686	-1,419
Load with Safety Factor	-19,428	-4,512	-2,203	-2,848	-1,867	-1,819	-1,774	-1,774	-858	-1,774
BTU/Hr/SF		-3	-3	-3	-3	-3	-3	-3	-3	-3
LAT for Max cfm		67.4	66.7	66.5	68.5	68.5	68.5	68.4	66.3	66.3
LAT for Min cfm		70.5	68.3	67.7	74.2	74.4	74.2	73.8	67.0	67.1
CFM for Max Htg LAT		144	70	91	60	58	57	57	27	57
Reheat + Heating (BTU/Hr)	58,030	6,418	8,370	15,328	628	557	602	721	9,003	16,402

HVAC Load Calculations - CINT Smart Lab - Air Handling Unit 1

Based on 1997 ASHRAE Handbook CLTD/SCL/CLF Method

Project:	HVU1 Heat Calcs - All Labs Sealed
Project No.:	
Date:	June 19, 2019
Calcs By:	Matney Juntunen
Block or Terminal Loads	Block

INPUT

General Data

Project Location:	TA-03-1420	
Project Latitude:		deg. N.
Weather Data Source	2017 ASHRAE Handbook of Fundamentals, Chapter 14	
Summer Criteria	1.0	% Occurance
Winter Criteria	99.6	% Occurance
Safety Factor - Cooling	0	%
Safety Factor - Heating	25	%

System Description	HVA-1 Heat Load Calculations	
Summer Outside Design Temerature	89	degF
Inside Summer Design Temperature	75	degF (Default value)
Summer SA Temperature	55	degF
Winter Outside Design Temerature	5	degF
Inside Winter Design Temperature	72	degF (Default value)
Max. Winter SA Temperature	95	degF
Min. SA Airflow Percentage	30	%
Infiltration - Air Change Method	0.25	Air Changes/Hr
Infiltration - Air Leakage Method	0.05	CFM/sf of Wall/Glass surface
People - Sensible Heat	250	BTU/Hr/ Person
People - Latent Heat	160	BTU/Hr/ Person

Room Data	**Room Description**	Bio: 1 Hood, 1 Lg. Freezer	Bio: 1 Vac Cabinet, 3 Lg. Freezers	Walk-In Freezer	Bio: 1 Snork, 1 Lg. Freezer	Bio: 1 Vac Cabinet, 1 Lg. Freezer	Bio: 1 Vac Cabinet, 1 Lg. Freezer	6 Hoods, 2 Vac, 2 Lg. Freezer	Heavy Laser
Room No.:		2201	2207/2207A	2207B	2207C	2207D	2207E	2204	2210
Room Name:									
Peak Cooling Month									
Peak Cooling Time									
Summer Inside Temp (^oF)		70	70	70	70	70	70	70	70
Winter Inside Temp (^oF)		66	66	66	66	66	66	66	66
Safety Factor - Summer (%)		0	0	0	0	0	0	0	0
Safety Factor - Winter (%)		25	25	25	25	25	25	25	25
Room Width (ft)									
Room Length (ft)									
Room Height (ft)		10	10	10	10	10	10	10	10
Room Floor Area (sf)	3,573	835	398	162	286	147	139	1,089	517
Room Volume (ft^3)	35,730	8,350	3,980	1,620	2,860	1,470	1,390	10,890	5,170
Ceiling/Parition 1 - Room Name									
Ceiling/Patition 1 Area (sf)	0								
Parition Summer Temp (^oF)									
Parition Winter Temp (^oF)									
Parition 2 - Room Name									
Patition 2 Area (sf)	0								
Parition 2 Summer Temp (^oF)									
Parition 2 Winter Temp (^oF)									
Parition 3 - Room Name									
Patition 3 Area (sf)	0								
Parition 3 Summer Temp (^oF)									
Parition 3 Winter Temp (^oF)									
Roof Net Area (sf)	0								
Skylight Area (sf)	0								
Exposed Floor Area:	0								
Slab Edge Length (ft)	0								
Below Gr Wall Area (sf)	0								
Below Gr. Floor Area (sf)	0								
Wall 1 Direction (N, NE..)									
Wall 1 Net Area (sf)	0								
Fenestration 1 Area (sf)	0								

Room No.:		2201	2207/2207A	2207B	2207C	2207D	2207E	2204	2210
Room Name:									
Fenestration 1 Infilration (cfm)	0								
Door 1 Area (sf)	0								
Door 1 Infiltration (cfm)	0								
Wall 2 Direction (N, NE..)									
Wall 2 Net Area (sf)	0								
Fenestration 2 Area (sf)	0								
Fenestration 2 Infilration (cfm)	0								
Door 2 Area (sf)	0								
Door 2 Infiltration (cfm)	0								
Wall 3 Direction (N, NE..)									
Wall 3 Net Area (sf)	0								
Fenestration 3 Area (sf)	0								
Fenestration 3 Infilration (cfm)	0								
Door 3 Area (sf)	0								
Door 3 Infiltration (cfm)	0								
Wall 4 Direction (N, NE..)									
Wall 4 Net Area (sf)	0								
Fenestration 4 Area (sf)	0								
Fenestration 4 Infilration (cfm)	0								
Door 4 Area (sf)	0								
Door 4 Infiltration (cfm)	0								
People Type 1 - BTUH/Per. - Sensible		275	275	275	275	275	275	275	275
People Type 1 - BTUH/Per. - latent		475	475	475	475	475	475	475	475
No. of People - Type 1		2	2	2	2	2	2	3	2
People/1000 sf - Type 1									
People Type 2 - BTUH/Per. - Sensible									
People Type 2 - BTUH/Per. - latent									
No. of People - Type 2									
People/1000 sf - Type 2									
Total No. of People	17	2	2	2	2	2	2	3	2
Lights (Watts) -Type 1		570	285	0	285	228	228	912	456
LIghts (Watts/sf) - Type 1		0.7	0.7	0.0	1.0	1.6	1.6	0.8	0.9
% of Lights to Space (0-100%) - Type 1		50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%
Lights (Watts) - Type 2		228.0	76.0					171.0	
LIghts (Watts/sf) - Type 2		0.27	0.19	0.00	0.00	0.00	0.00	0.16	0.00
% of Lights to Space (0-100%) - Type 2		50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%
Tot. Lighting Watts to Space	3,358	798	338	0	285	228	228	1025	456
Tot.Lighting Watts to Plenum	3,520	798.00	384	0	285	228	228	1141	456
Equipment 1 (watts) - **2 Desktops**		400	400	400	400	400	400	400	400
Equipment 1 (BTU/H Sens.)									
Equipment 1 (BTU/H Lat.)									
Equipment 2 (watts) - **Freezers**		1100	3300		1100	1100	1100	2200	
Equipment 2 (BTU/H Sens.)								18000	
Equipment 2 (BTU/H Lat.)									
Equipment 3 (watts) - **Hoods, Chillers, Lasers**		1991.86						11951.15	22349.52
Equipment 3 (BTU/H Sens.)			200			200	200	400	
Equipment 3 (BTU/H Lat.)									
Total Equip.(BTU/H Sens.)	187,429	11907.2372	12817	1364	5115	5315	5315	68019.4235	77575.8709
Total Equip.(BTU/H Lat.)	0	0	0	0	0	0	0	0	0

Summer U-factor Data

Roof	0.0188	0.0188	0.0188	0.0188	0.0188	0.0188	0.0188	0.0188
Skylight								
Exposed Floor								
Wall 1								
Wall 2								
Wall 3								
Wall 4								
Fenestration 1								
Fenestration 2								
Fenestration 3								
Fenestration 4								
Door 1								
Door 2								
Door 3								
Door 4								
Ceiling/Partition 1								
Partition 2								
Partition 3								

Room No.:	2201	2207/2207A	2207B	2207C	2207D	2207E	2204	2210
Room Name:								

Winter U-factor Data

Roof	0.0192	0.0192	0.0192	0.0192	0.0192	0.0192	0.0192	0.0192
Skylight - N/A								
Exposed Floor - N/A								
Slab Edge (BTU/Hr-F-LF) - N/A								
Below Gr. Walls (BTU/Hr-F-SF) - N/A								
Below Gr. Floors (BTU/H-SF) - N/A								
Wall 1								
Wall 2								
Wall 3								
Wall 4								
Fenestration 1								
Fenestration 2								
Fenestration 3								
Fenestration 4								
Door 1 - wood								
Door 2								
Door 3								
Door 4								
Ceiling/Partition 1								
Partition 2								
Partition 3								

CLTD (Cooling Load Temperature Difference) Values

Roof								
Wall 1								
Wall 2								
Wall 3								
Wall 4								
Fenestration 1								
Fenestration 2								
Fenestration 3								
Fenestration 4								
Door 1								
Door 2								
Door 3								
Door 4								

SC (Solar Coefficient glass) x IAC (shading) Values

Skylight								
Fenestration 1								
Fenestration 2								
Fenestration 3								
Fenestration 4								

SCF (Solar Cooling Load Factor) Values

Skylight								
Fenestration 1								
Fenestration 2								
Fenestration 3								
Fenestration 4								

CLF (Cooling Load Factor) Values

People - Type 1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
People - Type 2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Lights - Type 1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Lights - Type 2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Equipment 1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Equipment 2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Equipment 3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

F_U Use Factors

People - Type 1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
People - Type 2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Lights - Type 1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Lights - Type 2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Equipment 1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Room No.:		2201	2207/2207A	2207B	2207C	2207D	2207E	2204	2210
Room Name:									
Equipment 2		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Equipment 3		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

OUTPUT

Cooling Load (Summer - Sensible)

	System Totals								
Roof	0	0	0	0	0	0	0	0	0
Skylight - Transmission	0	0	0	0	0	0	0	0	0
Skylight - Solar	0	0	0	0	0	0	0	0	0
Exposed Floor	0	0	0	0	0	0	0	0	0
Walls	0	0	0	0	0	0	0	0	0
Fenestration - Transmission	0	0	0	0	0	0	0	0	0
Fenestration - Solar	0	0	0	0	0	0	0	0	0
Doors	0	0	0	0	0	0	0	0	0
Ceiling/Parition 1	0	0	0	0	0	0	0	0	0
Other Paritions	0	0	0	0	0	0	0	0	0
People	4,675	550	550	550	550	550	550	825	550
Lights	11,727	2,721	1,231	0	972	777	777	3,693	1,555
Equipment	187,429	11,907	12,817	1,364	5,115	5,315	5,315	68,019	77,576
Total Heat Load (BTU/Hr)	203,831	15,178	14,598	1,914	6,637	6,642	6,642	72,537	79,681
Load with Safety Factor	203,831	15,178	14,598	1,914	6,637	6,642	6,642	72,537	79,681
BTU/Hr/SF		18	37	12	23	45	48	67	154
Max cfm	12,590	940	900	120	410	410	410	4,480	4,920
Min cfm	3,770	280	270	40	120	120	120	1,340	1,480
Max cfm/sf	3.5	1.1	2.3	0.7	1.4	2.8	2.9	4.1	9.5
Min cfm/sf	1.1	0.3	0.7	0.2	0.4	0.8	0.9	1.2	2.9

Cooling Load (Summer - Latent)

People	8,075	950	950	950	950	950	950	1,425	950
Equipment	0	0	0	0	0	0	0	0	0
Total	8,075	950	950	950	950	950	950	1,425	950

Heat Loss (Winter)

	System Totals								
Roof	0	0	0	0	0	0	0	0	0
Skylight	0	0	0	0	0	0	0	0	0
Exposed Floor	0	0	0	0	0	0	0	0	0
Slab Edge	0	0	0	0	0	0	0	0	0
Below Gr Walls	0	0	0	0	0	0	0	0	0
Below Gr Floor	0	0	0	0	0	0	0	0	0
Walls	0	0	0	0	0	0	0	0	0
Fenestration	0	0	0	0	0	0	0	0	0
Doors	0	0	0	0	0	0	0	0	0
Ceiling /Partition 1	0	0	0	0	0	0	0	0	0
Other Partitions	0	0	0	0	0	0	0	0	0
Total Infiltration CFM	149	35	17	7	12	6	6	45	22
Infiltration BTU/Hr	-9,808	-2,292	-1,093	-445	-785	-404	-382	-2,989	-1,419
Total Heat Loss (BTU/Hr)	-9,808	-2,292	-1,093	-445	-785	-404	-382	-2,989	-1,419
Load with Safety Factor	-12,260	-2,865	-1,366	-556	-981	-504	-477	-3,737	-1,774
BTU/Hr/SF		-3	-3	-3	-3	-3	-3	-3	-3
LAT for Max cfm		68.8	67.4	70.3	68.2	67.1	67.1	66.8	66.3
LAT for Min cfm		75.5	70.7	78.9	73.6	69.9	69.7	68.6	67.1
CFM for Max Htg LAT		91	44	18	31	16	15	119	57
Reheat + Heating (BTU/Hr)	32,528	461	1,842	-81	444	921	949	12,183	15,808

A.3 AHU-2 HEAT LOAD CALCULATIONS (ASHRAE)

HVAC Load Calculations - CINT Smart Lab - Air Handling Unit 2

Based on 1997 ASHRAE Handbook CLTD/SCL/CLF Method

Project:	HVA2 Heat Calcs - No lab infiltration, All LED Lights
Project No.:	
Date:	July 8, 2019
Calcs By:	Matney Juntunen
Block or Terminal Loads	

HVA2 Summer

Total 1st Floor Cool Demand:	162,305	BTU/Hr
Total HVU2 Cool Demand:	234,739	BTU/Hr
Total HVU2 Cool Demand:	12,361.17	CFM

HVA2 Winter

Total 1st Floor Heat Demand:	-26,364	BTU/Hr
Total HVU2 Heat Demand:	-48,857	BTU/Hr
Total HVU2 Heat Demand:	(482.11)	CFM

HVA2 Spring/Fall:	92,941	BTU/Hr
	6,422	CFM

Cooling

Summer Dry bulb (F):	89	Summer MA change in enthalpy: HVA2	
Summer Relative Humidity:	30%	Inside temp:	75
Summer design temp indoors:	75	Outside temp:	89
Summer Delta Enthalpy:	4.22	MA temp:	77.1
		Change in enthalpy:	-1.2

Heating

Winter Dry bulb (F):	5	Winter MA change in enthalpy: HVA2	
Winter Relative Humidity:	30%	Inside temp:	72
Winter design temp indoors:	72	Outside temp:	5
Winter Delta Enthalpy:	22.52	MA temp:	61.95
		Change in enthalpy:	4.6

BTU/Hr = CFM*4.5*deltaenthalpy

INPUT

General Data

Project Location:	TA-03-1420	
Project Latitude:		deg. N.
Weather Data Source	2017 ASHRAE Handbook of Fundamentals, Chapter 14	
Summer Criteria	1.0	% Occurance
Winter Criteria	99.6	% Occurance
Safety Factor - Cooling	0	%
Safety Factor - Heating	25	%
System Description	Offices and Cooridoors	
Summer Outside Design Temerature	89	degF
Inside Summer Design Temperature	78	degF (Default value)
Summer SA Temperature	55	degF
Winter Outside Design Temerature	5	degF
Inside Winter Design Temperature	72	degF (Default value)
Max. Winter SA Temperature	95	degF
Min. SA Airflow Percentage	30	%
Infiltration - Air Change Method	0.25	Air Changes/Hr
Infiltration - Air Leakage Method	0.05	CFM/sf of Wall/Glass surface
People - Sensible Heat	250	BTU/Hr/ Person
People - Latent Heat	160	BTU/Hr/ Person

Office
Conference
Min. Ventilation
Hall/Corridor

Room Data	Room Description	1 dt, 2 ppl	2 dt, 2 ppl	3 dt, 3 ppl	1 dt, 2 ppl	1 dt, 2 ppl	1 dt, 2 ppl	6 ppl, 1 tv	Copy/print, telecom, elec	3 dt, 3 ppl	Showers and Toilets	Storage	Break Room	Kitchenette	Bathroom
Room No.:		**1102**	**1102A**	**1104**	**1106, 1108, 1110, 1112**	**1113, 1115,1117, 1119, 1121**	**1116, 1118**	**1126**	**1120, 1122, 1124**	**1302, 1304, 1306**	**1300A, 1310,1312, 1316, 1314**	**1318, 1324**	**1123**	**1322, 1320**	**1212, 1214**
Room Name:															
Peak Cooling Month		7	7	7	7	7	7	7	7	7	7	7	7	7	7
Peak Cooling Time		1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400
Summer Inside Temp (°F)		78	78	78	78	78	78	78	78	78	78	78	78	78	78
Winter Inside Temp (°F)		72	72	72	72	72	72	72	72	72	72	72	72	72	72
Safety Factor - Summer (%)		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Safety Factor - Winter (%)		25	25	25	25	25	25	25	25	25	25	25	25	25	25
Room Width (ft)															
Room Length (ft)															
Room Height (ft)		9	9	9	9	8.5	9	9	9	9	8.8	9	8	8	9
Room Floor Area (sf)	4,588	108	129	217	509	720	240	196	296	674	409	210	368	169	343
Room Volume (ft^3)	40,313	972	1,161	1,953	4,581	6,120	2,160	1,764	2,664	6,066	3,599	1,890	2,944	1,352	3,087
Ceiling/Parition 1 - Room Name															
Ceiling/Patition 1 Area (sf)	0														
Parition Summer Temp (°F)															
Parition Winter Temp (°F)															
Parition 2 - Room Name															
Patition 2 Area (sf)	0														
Parition 2 Summer Temp (°F)															
Parition 2 Winter Temp (°F)															
Parition 3 - Room Name															
Patition 3 Area (sf)	0														
Parition 3 Summer Temp (°F)															
Parition 3 Winter Temp (°F)															
Roof Net Area (sf)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Skylight Area (sf)	0														
Exposed Floor Area:	4,588	108	129	217	509	720	240	196	296	674	409	210	368	169	343
Slab Edge Length (ft)	210					132		8.75					45.25	13.75	10
Below Gr Wall Area (sf)	0														
Below Gr. Floor Area (sf)	0														
Wall 1 Direction (N, NE..)		N/A	N/A	N/A	N/A	N	N/A	E	N/A	N/A	N/A	N/A	N	E	E
Wall 1 Net Area (sf)	642	0	0	0	0	90	0	77.904	0	0	0	0	268	110	96.0102
Fenestration 1 Area (sf)	961	0	0	0	0	561	0	72	0	0	0	0	312	16	0
Fenestration 1 Infilration (cfm)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Door 1 Area (sf)	79	0	0	0	0	0	0	0	0	0	79.2	0	0	0	0
Door 1 Infiltration (cfm)	2	0	0	0	0	0	0	0	0	0	2	0	0	0	0
Wall 2 Direction (N, NE..)													E	W	W
Wall 2 Net Area (sf)	88												88	0	0
Fenestration 2 Area (sf)	92												92	0	0
Fenestration 2 Infilration (cfm)	0												0	0	0
Door 2 Area (sf)	105												27	24	54
Door 2 Infiltration (cfm)	6												0	2	4
Wall 3 Direction (N, NE..)															
Wall 3 Net Area (sf)	0														
Fenestration 3 Area (sf)	0														
Fenestration 3 Infilration (cfm)	0														
Door 3 Area (sf)	0														
Door 3 Infiltration (cfm)	0														
Wall 4 Direction (N, NE..)															
Wall 4 Net Area (sf)	0														
Fenestration 4 Area (sf)	0														
Fenestration 4 Infilration (cfm)	0														
Door 4 Area (sf)	0														
Door 4 Infiltration (cfm)	0														
People Type 1 - BTUH/Per. - Sensible		250	250	250	250	250	250	250	250	250	250	250	250	250	250
People Type 1 - BTUH/Per. - latent		160	160	160	160	160	160	160	160	160	160	160	160	160	160
No. of People - Type 1		2	2	3	2	2	2	6	0	3	1	0	4	2	2
People/1000 sf - Type 1															
People Type 2 - BTUH/Per. - Sensible															
People Type 2 - BTUH/Per. - latent															
No. of People - Type 2															
People/1000 sf - Type 2															
Total No. of People	31	2	2	3	2	2	2	6	0	3	1	0	4	2	2
Lights (Watts) -Type 1		76	114	228	456	684	228	171	285	864	266	152	52	114	380
LIghts (Watts/sf) - Type 1		0.7	0.9	1.1	0.9	1.0	1.0	0.9	1.0	1.3	0.7	0.7	0.1	0.7	1.1
% of Lights to Space (0-100%) - Type 1		50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%
Lights (Watts) - Type 2								52.0			26.0	57.0	171.0	38.0	
LIghts (Watts/sf) - Type 2		0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.1	0.3	0.5	0.2	0.0
% of Lights to Space (0-100%) - Type 2		50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%
Tot. Lighting Watts to Space	4,362	76	114	228	456	684	228	211	285	864	281	196	217	142	380
Tot.Lighting Watts to Plenum	2,715	76	65	109	255	360	120	162	148	337	242	175	361	133	172
Equipment 1 (watts) - **"Desktop set-up"**		200	400	600	200	200	200			600					
Equipment 1 (BTU/H Sens.)															
Equipment 1 (BTU/H Lat.)															
Equipment 2 (watts) - **Other Technology**								415	1100						
Equipment 2 (BTU/H Sens.)															
Equipment 2 (BTU/H Lat.)															
Equipment 3 (watts) - **Kitchen Things**													2750	14930	
Equipment 3 (BTU/H Sens.)															
Equipment 3 (BTU/H Lat.)															
Total Equip.(BTU/H Sens.)	73,639	682	1364	2046	682	682	682	1415.15	3751	2046	0	0	9377.5	50911.3	0
Total Equip.(BTU/H Lat.)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Summer U-factor Data

Roof														
Skylight														
Exposed Floor	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.14	0.39	1.73	0.14	0.39	0.14	1.73

Room No.:	1102	1102A	1104	1106, 1108, 1110, 1112	1113, 1115,1117, 1119, 1121	1116, 1118	1126	1120, 1122, 1124	1302, 1304, 1306	1300A, 1310,1312, 1316, 1314	1318, 1324	1123	1322, 1320	1212, 1214
Room Name:														
Wall 1					0.0228		0.0228					0.0228		0.0228
Wall 2														
Wall 3														
Wall 4														
Fenestration 1 - Window	0.00	0.00	0.00	0.00	0.45	0.00	0.39	0.00	0.00	0.00	0.00	0.39	0.58	0.00
Fenestration 2												0.39		
Fenestration 3														
Fenestration 4														
Door 1														
Door 2														
Door 3														
Door 4														
Ceiling/Partition 1														
Partition 2														
Partition 3														

Winter U-factor Data

Roof														
Skylight														
Exposed Floor														
Slab Edge (BTU/Hr-F-LF)														
Below Gr. Walls (BTU/Hr-F-SF)														
Below Gr. Floors (BTU/H-SF)														
Wall 1														
Wall 2														
Wall 3														
Wall 4														
Fenestration 1														
Fenestration 2														
Fenestration 3														
Fenestration 4														
Door 1														
Door 2														
Door 3														
Door 4														
Ceiling/Partition 1														
Partition 2														
Partition 3														

CLTD (Cooling Load Temperature Difference) Values

Roof														
Wall 1					24		40					24	40	40
Wall 2												40		
Wall 3														
Wall 4														
Fenestration 1					14		14					14	14	
Fenestration 2												14		
Fenestration 3														
Fenestration 4														
Door 1														
Door 2														
Door 3														
Door 4														

SC (Solar Coefficient glass) x IAC (shading) Values

Skylight														
Fenestration 1														
Fenestration 2														
Fenestration 3														
Fenestration 4														

SCF (Solar Cooling Load Factor) Values

Skylight														
Fenestration 1	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Fenestration 2	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Fenestration 3	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Fenestration 4	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89

CLF (Cooling Load Factor) Values

People - Type 1	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
People - Type 2	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Lights - Type 1	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Lights - Type 2	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Equipment 1	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Equipment 2	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Equipment 3	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89

F_U Use Factors

People - Type 1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
People - Type 2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Lights - Type 1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Lights - Type 2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Equipment 1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Equipment 2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Equipment 3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

OUTPUT

Cooling Load (Summer - Sensible)

	System Totals														
Roof	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Skylight - Transmission	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Skylight - Solar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Exposed Floor	28,916	463	553	931	2,184	3,089	1,030	841	470	2,891	7,769	333	1,579	268	6,515
Walls	354	0	0	0	0	49	0	71	0	0	0	0	147	0	88
Fenestration - Transmission	6,263	0	0	0	0	3,534	0	393	0	0	0	0	2,206	130	0
Fenestration - Solar	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Doors	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ceiling/Parition 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Paritions	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
People	6,898	445	445	668	445	445	445	1,335	0	668	223	0	890	445	445
Lights	14,149	244	365	731	1,462	2,192	731	715	914	2,769	936	670	715	487	1,218
Equipment	65,539	607	1,214	1,821	607	607	607	1,259	3,338	1,821	0	0	8,346	45,311	0
Total Heat Load (BTU/Hr)	122,119	1,759	2,578	4,150	4,697	9,917	2,812	4,614	4,722	8,149	8,927	1,003	13,882	46,641	8,266
Load with Safety Factor	122,119	1,759	2,578	4,150	4,697	9,917	2,812	4,614	4,722	8,149	8,927	1,003	13,882	46,641	8,266
BTU/Hr/SF		16	20	19	9	14	12	24	16	12	22	5	38	276	24
Max cfm	4,920	70	100	170	190	400	110	190	190	330	360	40	560	1,880	330
Min cfm	1,480	20	30	50	60	120	30	60	60	100	110	10	170	560	100
Max cfm/sf	1.1	0.6	0.8	0.8	0.4	0.6	0.5	1.0	0.6	0.5	0.9	0.2	1.5	11.1	1.0
Min cfm/sf	0.3	0.2	0.2	0.2	0.1	0.2	0.1	0.3	0.2	0.1	0.3	0.0	0.5	3.3	0.3

Cooling Load (Summer - Latent)

People	3,040	320	320	480	320	320	320	960	0	480	160	0	640	320	320
Equipment	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	3,040	320	320	480	320	320	320	960	0	480	160	0	640	320	320

Heat Loss (Winter)

	System Totals														
Roof	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Skylight	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Room No.:		1102	1102A	1104	1106, 1108, 1110, 1112	1113, 1115,1117, 1119, 1121	1116, 1118	1126	1120, 1122, 1124	1302, 1304, 1306	1300A, 1310,1312, 1316, 1314	1318, 1324	1123	1322, 1320	1212, 1214
Room Name:															
Exposed Floor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Slab Edge	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Below Gr Walls	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Below Gr Floor	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Walls	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fenestration	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Doors	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ceiling /Partition 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Partitions	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Infiltration CFM	86	4	5	8	19	30	9	11	11	25	17	8	30	13	22
Infiltration BTU/Hr	-6,249	-293	-350	-589	-1,381	-2,171	-651	-814	-803	-1,829	-1,230	-570	-2,176	-950	-1,568
Total Heat Loss (BTU/Hr)	-6,249	-293	-350	-589	-1,381	-2,171	-651	-814	-803	-1,829	-1,230	-570	-2,176	-950	-1,568
Load with Safety Factor	-7,811	-366	-438	-736	-1,726	-2,714	-814	-1,017	-1,004	-2,286	-1,537	-712	-2,720	-1,188	-1,959
BTU/Hr/SF		-3	-3	-3	-3	-4	-3	-5	-3	-3	-4	-3	-7	-7	-6
LAT for Max cfm		76.8	76.1	76.0	80.4	78.3	78.9	77.0	76.9	78.4	76.0	88.5	76.5	72.6	77.5
LAT for Min cfm		89.0	85.5	85.6	98.6	92.9	97.1	87.7	87.5	93.2	84.9	138.0	86.8	74.0	90.1
CFM for Max Htg LAT		15	18	30	70	109	33	41	40	92	62	29	109	48	79
Reheat + Heating (BTU/Hr)	-792	1	113	182	-450	-510	-212	84	98	-450	482	-186	402	9,094	-123

HVAC Load Calculations - CINT Smart Lab - Air Handling Unit 2

Based on 1997 ASHRAE Handbook CLTD/SCL/CLF Method

Project:	HVA2 Heat Calcs - No lab infiltration, All LED Lights
Project No.:	
Date:	July 8, 2019
Calcs By:	Matney Juntunen
Block or Terminal Loads	

INPUT

General Data

Project Location:	TA-03-1420	
Project Latitude:		deg. N.
Weather Data Source	2017 ASHRAE Handbook of Fundamentals, Chapter 14	
Summer Criteria	1.0	% Occurance
Winter Criteria	99.6	% Occurance
Safety Factor - Cooling	0	%
Safety Factor - Heating	25	%

System Description	Offices and Corridors	
Summer Outside Design Temerature	89	degF
Inside Summer Design Temperature	78	degF (Default value)
Summer SA Temperature	55	degF
Winter Outside Design Temerature	5	degF
Inside Winter Design Temperature	72	degF (Default value)
Max. Winter SA Temperature	95	degF
Min. SA Airflow Percentage	30	%
Infiltration - Air Change Method	0.25	Air Changes/Hr
Infiltration - Air Leakage Method	0.05	CFM/sf of Wall/Glass surface
People - Sensible Heat	250	BTU/Hr/ Person
People - Latent Heat	200	BTU/Hr/ Person

Office
Conference
Min. Ventilation
Hall/Corridor

Room Data	Room Description	Hall	Hall	Hall	Hall	Hall	Hall	Hall	Hall	Hall	Elec/Hall
Room No.:		**1000A**	**1100**	**1100B**	**1100C**	**1200A**	**1200D**	**1000B**	**1300**	**1200C**	**1308**
Room Name:											
Peak Cooling Month		7	7	7	7	7	7	7	7	7	7
Peak Cooling Time		1400	1400	1400	1400	1400	1400	1400	1400	1400	1400
Summer Inside Temp (°F)		78	78	78	78	78	78	78	78	78	78
Winter Inside Temp (°F)		72	72	72	72	72	72	72	72	72	72
Safety Factor - Summer (%)		0	0	0	0	0	0	0	0	0	0
Safety Factor - Winter (%)		25	25	25	25	25	25	25	25	25	25
Room Width (ft)											
Room Length (ft)											
Room Height (ft)		9	9	9	9	9	9	9	9	9	9
Room Floor Area (sf)	5,514	798	141	531	607	266	1,430	480	813	225	223
Room Volume (ft^3)	47,619	7,182	1,269	4,779	5,463	2,394	12,870	4,320	7,317	2,025	2,007
Ceiling/Parition 1 - Room Name											
Ceiling/Patition 1 Area (sf)	0										
Parition Summer Temp (°F)											
Parition Winter Temp (°F)											
Parition 2 - Room Name											
Patition 2 Area (sf)	0										
Parition 2 Summer Temp (°F)											
Parition 2 Winter Temp (°F)											
Parition 3 - Room Name											
Patition 3 Area (sf)	0										
Parition 3 Summer Temp (°F)											
Parition 3 Winter Temp (°F)											
Roof Net Area (sf)	0	0	0	0	0	0	0	0	0	0	0
Skylight Area (sf)	0	0	0	0	0	0	0	0	0	0	0
Exposed Floor Area:	5,291	798	141	531	607	266	1,430	480	813	225	223
Slab Edge Length (ft)	143		32.75	33			29.75	47.5			
Below Gr Wall Area (sf)	0										
Below Gr. Floor Area (sf)	0										
Wall 1 Direction (N, NE..)		W	N	N	N/A	N/A	S	E	N/A	N/A	N/A
Wall 1 Net Area (sf)	1,592	309.06	297	297	0	0	267.75	420.75	0	0	0
Fenestration 1 Area (sf)	742	387	306	32.5	0	0	0	16	0	0	0
Fenestration 1 Infilration (cfm)	0				0	0			0	0	0
Door 1 Area (sf)	0	0	0	0	0	0	0	0	0	0	0
Door 1 Infiltration (cfm)	0	0	0	0	0	0	0	0	0	0	0
Wall 2 Direction (N, NE..)											
Wall 2 Net Area (sf)	0										
Fenestration 2 Area (sf)	0										
Fenestration 2 Infilration (cfm)	0										
Door 2 Area (sf)	0										

Room No.:		1000A	1100	1100B	1100C	1200A	1200D	1000B	1300	1200C	1308
Room Name:											
Door 2 Infiltration (cfm)	0										
Wall 3 Direction (N, NE..)											
Wall 3 Net Area (sf)	0										
Fenestration 3 Area (sf)	0										
Fenestration 3 Infilration (cfm)	0										
Door 3 Area (sf)	0										
Door 3 Infiltration (cfm)	0										
Wall 4 Direction (N, NE..)											
Wall 4 Net Area (sf)	0										
Fenestration 4 Area (sf)	0										
Fenestration 4 Infilration (cfm)	0										
Door 4 Area (sf)	0										
Door 4 Infiltration (cfm)	0										
People Type 1 - BTUH/Per. - Sensible		250	250	250	250	250	250	250	250	250	250
People Type 1 - BTUH/Per. - latent		200	200	200	200	200	200	200	200	200	200
No. of People - Type 1		3	0	3	0	0	0	0	5	0	0
People/1000 sf - Type 1											
People Type 2 - BTUH/Per. - Sensible											
People Type 2 - BTUH/Per. - latent											
No. of People - Type 2											
People/1000 sf - Type 2											
Total No. of People	11	3	0	3	0	0	0	0	5	0	0
Lights (Watts) -Type 1		285	114	228	152	114	418	114	266	76	152
LIghts (Watts/sf) - Type 1		0.4	0.8	0.4	0.3	0.4	0.3	0.2	0.3	0.3	0.7
% of Lights to Space (0-100%) - Type 1		50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%
Lights (Watts) - Type 2			152.0	78.0			39.0			26.0	
LIghts (Watts/sf) - Type 2		0.0	1.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0
% of Lights to Space (0-100%) - Type 2		50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%
Tot. Lighting Watts to Space	2,096	285	354	279	152	114	439	114	266	93	152
Tot.Lighting Watts to Plenum	2,795	285	135	371	304	133	772	240	407	148	112
Equipment 1 (watts)											
Equipment 1 (BTU/H Sens.)											
Equipment 1 (BTU/H Lat.)											
Equipment 2 (watts)											
Equipment 2 (BTU/H Sens.)											
Equipment 2 (BTU/H Lat.)											
Equipment 3 (watts)											
Equipment 3 (BTU/H Sens.)											
Equipment 3 (BTU/H Lat.)											
Total Equip.(BTU/H Sens.)	0	0	0	0	0	0	0	0	0	0	0
Total Equip.(BTU/H Lat.)	0	0	0	0	0	0	0	0	0	0	0

Summer U-factor Data

Roof										
Skylight										
Exposed Floor	1.73	0.39	0.14	0.39	0.39	0.14	0.39	0.14	0.14	0.14
Wall 1	0.0228	0.0228	0.0228			0.0228				
Wall 2										
Wall 3										
Wall 4										
Fenestration 1	0.38	0.46	0.46	0.00	0.00	0.00	0.00	0.00	0.00	
Fenestration 2										
Fenestration 3										
Fenestration 4										
Door 1										
Door 2										
Door 3										
Door 4										
Ceiling/Partition 1										
Partition 2										
Partition 3										

Winter U-factor Data

Roof										
Skylight										
Exposed Floor										
Slab Edge (BTU/Hr-F-LF)										
Below Gr. Walls (BTU/Hr-F-SF)										
Below Gr. Floors (BTU/H-SF)										
Wall 1										
Wall 2										
Wall 3										
Wall 4										
Fenestration 1										
Fenestration 2										

Room No.:	1000A	1100	1100B	1100C	1200A	1200D	1000B	1300	1200C	1308
Room Name:										
Fenestration 3										
Fenestration 4										
Door 1										
Door 2										
Door 3										
Door 4										
Ceiling/Partition 1										
Partition 2										
Partition 3										

CLTD (Cooling Load Temperature Difference) Values

Roof										
Wall 1		24	24			39	30			
Wall 2										
Wall 3										
Wall 4										
Fenestration 1	14	14	14							
Fenestration 2										
Fenestration 3										
Fenestration 4										
Door 1										
Door 2										
Door 3										
Door 4										

SC (Solar Coefficient glass) x IAC (shading) Values

Skylight										
Fenestration 1										
Fenestration 2										
Fenestration 3										
Fenestration 4										

SCF (Solar Cooling Load Factor) Values

Skylight										
Fenestration 1	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Fenestration 2	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Fenestration 3	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Fenestration 4	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89

CLF (Cooling Load Factor) Values

People - Type 1	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
People - Type 2	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Lights - Type 1	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Lights - Type 2	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Equipment 1	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Equipment 2	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Equipment 3	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89

F_U Use Factors

People - Type 1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
People - Type 2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Lights - Type 1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Lights - Type 2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Equipment 1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Equipment 2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Equipment 3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

OUTPUT

Cooling Load (Summer - Sensible)

	System Totals										
Roof	0	0	0	0	0	0	0	0	0	0	0
Skylight - Transmission	0	0	0	0	0	0	0	0	0	0	0
Skylight - Solar	0	0	0	0	0	0	0	0	0	0	0
Exposed Floor	26,328	15,158	605	843	2,604	1,141	2,270	2,059	1,291	357	354
Walls	563	0	162	162	0	0	238	0	0	0	0
Fenestration - Transmission	4,239	2,059	1,971	209	0	0	0	0	0	0	0
Fenestration - Solar	0	0	0	0	0	0	0	0	0	0	0
Doors	0	0	0	0	0	0	0	0	0	0	0
Ceiling/Parition 1	0	0	0	0	0	0	0	0	0	0	0
Other Paritions	0	0	0	0	0	0	0	0	0	0	0
People	2,448	668	0	668	0	0	0	0	1,113	0	0
Lights	6,610	914	853	981	487	365	1,465	365	853	327	487
Equipment	0	0	0	0	0	0	0	0	0	0	0
Total Heat Load (BTU/Hr)	40,187	18,798	3,591	2,863	3,091	1,507	3,973	2,425	3,256	684	841
Load with Safety Factor	40,187	18,798	3,591	2,863	3,091	1,507	3,973	2,425	3,256	684	841

Room No.:		1000A	1100	1100B	1100C	1200A	1200D	1000B	1300	1200C	1308
Room Name:											
BTU/Hr/SF		24	25	5	5	6	3	5	4	3	4
Max cfm	1,620	760	140	120	120	60	160	100	130	30	30
Min cfm	500	230	40	40	40	20	50	30	40	10	10
Max cfm/sf	0.3	1.0	1.0	0.2	0.2	0.2	0.1	0.2	0.2	0.1	0.1
Min cfm/sf	0.1	0.3	0.3	0.1	0.1	0.1	0.0	0.1	0.0	0.0	0.0

Cooling Load (Summer - Latent)

People	2,200	600	0	600	0	0	0	0	1,000	0	0
Equipment	0	0	0	0	0	0	0	0	0	0	0
Total	2,200	600	0	600	0	0	0	0	1,000	0	0

Heat Loss (Winter)

	System Totals										
Roof	0	0	0	0	0	0	0	0	0	0	0
Skylight	0	0	0	0	0	0	0	0	0	0	0
Exposed Floor	0	0	0	0	0	0	0	0	0	0	0
Slab Edge	0	0	0	0	0	0	0	0	0	0	0
Below Gr Walls	0	0	0	0	0	0	0	0	0	0	0
Below Gr Floor	0	0	0	0	0	0	0	0	0	0	0
Walls	0	0	0	0	0	0	0	0	0	0	0
Fenestration	0	0	0	0	0	0	0	0	0	0	0
Doors	0	0	0	0	0	0	0	0	0	0	0
Ceiling /Partition 1	0	0	0	0	0	0	0	0	0	0	0
Other Partitions	0	0	0	0	0	0	0	0	0	0	0
Total Infiltration CFM	278	45	20	35	23	10	67	39	30	8	8
Infiltration BTU/Hr	-20,115	-3,284	-1,457	-2,515	-1,647	-722	-4,849	-2,825	-2,206	-611	-605
Total Heat Loss (BTU/Hr)	-20,115	-3,284	-1,457	-2,515	-1,647	-722	-4,849	-2,825	-2,206	-611	-605
Load with Safety Factor	-25,144	-4,104	-1,821	-3,144	-2,059	-902	-6,061	-3,531	-2,758	-763	-756
BTU/Hr/SF		-5	-13	-6	-3	-3	-4	-7	-3	-3	-3
LAT for Max cfm		77.0	84.0	96.3	87.9	85.9	107.1	104.7	91.6	95.6	95.3
LAT for Min cfm		88.5	114.2	144.8	119.7	113.8	184.2	181.0	135.8	142.7	142.0
CFM for Max Htg LAT		165	73	127	83	36	244	142	111	31	30
Reheat + Heating (BTU/Hr)	-5,370	118	-475	-820	-537	-235	-1,581	-921	-719	-199	-197

HVAC Load Calculations - CINT Smart Lab - Air Handling Unit 2

Based on 1997 ASHRAE Handbook CLTD/SCL/CLF Method

Project:	HVA2 Heat Calcs - No lab infiltration, All LED Lights
Project No.:	
Date:	July 10, 2019
Calcs By:	Matney Juntunen
Block or Terminal Loads	

Total 2nd Floor Cooling Demand: 72,433 BTU/Hr

INPUT

General Data

Project Location:	TA-03-1420	
Project Latitude:		deg. N.
Weather Data Source	2017 ASHRAE Handbook of Fundamentals, Chapter 14	
Summer Criteria	1.0	% Occurance
Winter Criteria	99.6	% Occurance
Safety Factor - Cooling	0	%
Safety Factor - Heating	25	%

System Description	Offices and Corridors	
Summer Outside Design Temerature	89	degF
Inside Summer Design Temperature	78	degF (Default value)
Summer SA Temperature	55	degF
Winter Outside Design Temerature	5	degF
Inside Winter Design Temperature	72	degF (Default value)
Max. Winter SA Temperature	95	degF
Min. SA Airflow Percentage	30	%
Infiltration - Air Change Method	0.25	Air Changes/Hr
Infiltration - Air Leakage Method	0.05	CFM/sf of Wall/Glass surface
People - Sensible Heat	250	BTU/Hr/ Person
People - Latent Heat	200	BTU/Hr/ Person

Office
Conference
Min. Ventilation
Hall/Corridor

Room Data	Room Description	Break Room	32 ppl, 3 tv	2 ppl, 1 dt	2 ppl, 1 dt	2117: 2 ppl, 1 dt Others: 3 ppl, 3 dt	Bathrooms	Copier, Storage, etc.	Elec/Facility	3 ppl. 3 dt
Room No.:		2001	2101	2105, 2107, 2111, 2113	2117A	2117, 2119, 2121, 2123, 2311	2215, 2217	2316, 2314, 2312, 2318	2308	2301
Room Name:										
Peak Cooling Month		7	7	7	7	7	7	7	7	7
Peak Cooling Time		1400	1400	1400	1400	1400	1400	1400	1400	1400
Summer Inside Temp (°F)		78	78	78	78	78	78	78	78	78
Winter Inside Temp (°F)		72	72	72	72	72	72	72	72	72
Safety Factor - Summer (%)		0	0	0	0	0	0	0	0	0
Safety Factor - Winter (%)		25	25	25	25	25	25	25	25	25
Room Width (ft)										
Room Length (ft)										
Room Height (ft)		9	8.5	8.5	9	9	9	9	9	9
Room Floor Area (sf)	4,035	340	596	516	264	1,074	343	361	216	325
Room Volume (ft^3)	35,759	3,060	5,066	4,386	2,376	9,666	3,087	3,249	1,944	2,925
Ceiling/Parition 1 - Room Name										
Ceiling/Patition 1 Area (sf)	0									
Parition Summer Temp (°F)										
Parition Winter Temp (°F)										
Parition 2 - Room Name										
Patition 2 Area (sf)	0									
Parition 2 Summer Temp (°F)										
Parition 2 Winter Temp (°F)										
Parition 3 - Room Name										
Patition 3 Area (sf)	0									
Parition 3 Summer Temp (°F)										
Parition 3 Winter Temp (°F)										
Roof Net Area (sf)	4,035	340	596	516	264	1,074	343	361	216	325
Skylight Area (sf)	0									
Exposed Floor Area:	0									
Slab Edge Length (ft)	0									
Below Gr Wall Area (sf)	0									
Below Gr. Floor Area (sf)	0									
Wall 1 Direction (N, NE..)		N	N	N	N	E	N/A	N/A	N/A	N/A
Wall 1 Net Area (sf)	0						0	0	0	0
Fenestration 1 Area (sf)	996	189	187	374	198	48	0	0	0	0
Fenestration 1 Infilration (cfm)	0						0	0	0	0
Door 1 Area (sf)	0						0	0	0	0
Door 1 Infiltration (cfm)	0						0	0	0	0
Wall 2 Direction (N, NE..)					E					
Wall 2 Net Area (sf)	106				105.75					
Fenestration 2 Area (sf)	0									
Fenestration 2 Infilration (cfm)	0									
Door 2 Area (sf)	0									
Door 2 Infiltration (cfm)	0									
Wall 3 Direction (N, NE..)										
Wall 3 Net Area (sf)	0									
Fenestration 3 Area (sf)	0									
Fenestration 3 Infilration (cfm)	0									
Door 3 Area (sf)	0									

Room No.:		2001	2101	2105, 2107, 2111, 2113	2117A	2117, 2119, 2121, 2123, 2311	2215, 2217	2316, 2314, 2312, 2318	2308	2301
Room Name:										
Door 3 Infiltration (cfm)	0									
Wall 4 Direction (N, NE..)										
Wall 4 Net Area (sf)	0									
Fenestration 4 Area (sf)	0									
Fenestration 4 Infilration (cfm)	0									
Door 4 Area (sf)	0									
Door 4 Infiltration (cfm)	0									
People Type 1 - BTUH/Per. - Sensible		250	250	250	250	250	250	250	250	250
People Type 1 - BTUH/Per. - latent		200	200	200	200	200	200	200	200	200
No. of People - Type 1		4	32	8	2	14	2	0	0	3
People/1000 sf - Type 1										
People Type 2 - BTUH/Per. - Sensible										
People Type 2 - BTUH/Per. - latent										
No. of People - Type 2										
People/1000 sf - Type 2										
Total No. of People	65	4	32	8	2	14	2	0	0	3
Lights (Watts) -Type 1		342	117	456	171	114	380	342	304	228
LIghts (Watts/sf) - Type 1		1.0	0.2	0.9	0.6	0.1	1.1	0.9	1.4	0.7
% of Lights to Space (0-100%) - Type 1		50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%
Lights (Watts) - Type 2			684.0			912.0				
LIghts (Watts/sf) - Type 2		0.0	1.1	0.0	0.0	0.8	0.0	0.0	0.0	0.0
% of Lights to Space (0-100%) - Type 2		50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%
Tot. Lighting Watts to Space	4,812	342	1244	456	171	1345	380	342	304	228
Tot.Lighting Watts to Plenum	3,025	342	539	258	132	1130	172	181	108	163
Equipment 1 (watts)		2750	1245	200	200	2600	0	1100	0	600
Equipment 1 (BTU/H Sens.)										
Equipment 1 (BTU/H Lat.)										
Equipment 2 (watts)										
Equipment 2 (BTU/H Sens.)										
Equipment 2 (BTU/H Lat.)										
Equipment 3 (watts)										
Equipment 3 (BTU/H Sens.)										
Equipment 3 (BTU/H Lat.)										
Total Equip.(BTU/H Sens.)	29,650	9377.5	4245.45	682	682	8866	0	3751	0	2046
Total Equip.(BTU/H Lat.)	0	0	0	0	0	0	0	0	0	0
Summer U-factor Data										
Roof		0.0192	0.0192	0.0192	0.0192	0.0192	0.0192	0.0192	0.0192	0.0192
Skylight										
Exposed Floor										
Wall 1		0.0228	0.0228	0.0228	0.0228	0.0228	0.0228	0.00	0.00	0.00
Wall 2										
Wall 3										
Wall 4										
Fenestration 1		0.46	0.46	0.45	0.40	0.58	0.00	0.00	0.00	0.00
Fenestration 2					0.41					
Fenestration 3										
Fenestration 4										
Door 1										
Door 2										
Door 3										
Door 4										
Ceiling/Partition 1										
Partition 2										
Partition 3										
Winter U-factor Data										
Roof										
Skylight										
Exposed Floor										
Slab Edge (BTU/Hr-F-LF)										
Below Gr. Walls (BTU/Hr-F-SF)										
Below Gr. Floors (BTU/H-SF)										
Wall 1										
Wall 2										
Wall 3										
Wall 4										
Fenestration 1										
Fenestration 2										
Fenestration 3										
Fenestration 4										
Door 1										
Door 2										
Door 3										
Door 4										
Ceiling/Partition 1										
Partition 2										
Partition 3										
CLTD (Cooling Load Temperature Difference) Values										
Roof		39	39	39	39	39	39	39	39	39
Wall 1		24	24	24	24	40	40			

Room No.:	2001	2101	2105, 2107, 2111, 2113	2117A	2117, 2119, 2121, 2123, 2311	2215, 2217	2316, 2314, 2312, 2318	2308	2301
Room Name:									
Wall 2	30			40					
Wall 3									
Wall 4									
Fenestration 1	14	14	14	14	14				
Fenestration 2				14					
Fenestration 3									
Fenestration 4									
Door 1									
Door 2									
Door 3									
Door 4									

SC (Solar Coefficient glass) x IAC (shading) Values

Skylight									
Fenestration 1									
Fenestration 2									
Fenestration 3									
Fenestration 4									

SCF (Solar Cooling Load Factor) Values

Skylight									
Fenestration 1	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Fenestration 2	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Fenestration 3	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Fenestration 4	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89

CLF (Cooling Load Factor) Values

People - Type 1	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
People - Type 2	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Lights - Type 1	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Lights - Type 2	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Equipment 1	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Equipment 2	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
Equipment 3	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89

F_U Use Factors

People - Type 1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
People - Type 2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Lights - Type 1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Lights - Type 2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Equipment 1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Equipment 2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Equipment 3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

OUTPUT

Cooling Load (Summer - Sensible)

	System Totals									
Roof	3,021	255	446	386	198	804	257	270	162	243
Skylight - Transmission	0	0	0	0	0	0	0	0	0	0
Skylight - Solar	0	0	0	0	0	0	0	0	0	0
Exposed Floor	0	0	0	0	0	0	0	0	0	0
Walls	0	0	0	0	0	0	0	0	0	0
Fenestration - Transmission	6,276	1,217	1,204	2,356	1,109	390	0	0	0	0
Fenestration - Solar	0	0	0	0	0	0	0	0	0	0
Doors	0	0	0	0	0	0	0	0	0	0
Ceiling/Parition 1	0	0	0	0	0	0	0	0	0	0
Other Paritions	0	0	0	0	0	0	0	0	0	0
People	14,463	890	7,120	1,780	445	3,115	445	0	0	668
Lights	12,982	1,096	2,568	1,462	548	3,289	1,218	1,096	974	731
Equipment	26,388	8,346	3,778	607	607	7,891	0	3,338	0	1,821
Total Heat Load (BTU/Hr)	63,130	11,804	15,117	6,591	2,907	15,488	1,920	4,705	1,136	3,463
Load with Safety Factor	63,130	11,804	15,117	6,591	2,907	15,488	1,920	4,705	1,136	3,463
BTU/Hr/SF		35	25	13	11	14	6	13	5	11
Max cfm	2,560	480	610	270	120	620	80	190	50	140
Min cfm	770	140	180	80	40	190	20	60	20	40
Max cfm/sf	0.6	1.4	1.0	0.5	0.5	0.6	0.2	0.5	0.2	0.4
Min cfm/sf	0.2	0.4	0.3	0.2	0.2	0.2	0.1	0.2	0.1	0.1

Cooling Load (Summer - Latent)

People	13,000	800	6,400	1,600	400	2,800	400	0	0	600
Equipment	0	0	0	0	0	0	0	0	0	0
Total	13,000	800	6,400	1,600	400	2,800	400	0	0	600

Heat Loss (Winter)

	System Totals									
Roof	0	0	0	0	0	0	0	0	0	0
Skylight	0	0	0	0	0	0	0	0	0	0
Exposed Floor	0	0	0	0	0	0	0	0	0	0
Slab Edge	0	0	0	0	0	0	0	0	0	0
Below Gr Walls	0	0	0	0	0	0	0	0	0	0

Room No.:		2001	2101	2105, 2107, 2111, 2113	2117A	2117, 2119, 2121, 2123, 2311	2215, 2217	2316, 2314, 2312, 2318	2308	2301
Room Name:										
Below Gr Floor	0	0	0	0	0	0	0	0	0	0
Walls	0	0	0	0	0	0	0	0	0	0
Fenestration	0	0	0	0	0	0	0	0	0	0
Doors	0	0	0	0	0	0	0	0	0	0
Ceiling /Partition 1	0	0	0	0	0	0	0	0	0	0
Other Partitions	0	0	0	0	0	0	0	0	0	0
Total Infiltration CFM	154	13	21	18	15	40	13	14	8	12
Infiltration BTU/Hr	-11,164	-923	-1,527	-1,322	-1,099	-2,914	-931	-980	-586	-882
Total Heat Loss (BTU/Hr)	-11,164	-923	-1,527	-1,322	-1,099	-2,914	-931	-980	-586	-882
Load with Safety Factor	-13,955	-1,153	-1,909	-1,653	-1,374	-3,643	-1,163	-1,224	-733	-1,102
BTU/Hr/SF		-3	-3	-3	-5	-3	-3	-3	-3	-3
LAT for Max cfm		74.2	74.9	77.7	82.6	77.4	85.5	78.0	85.6	79.3
LAT for Min cfm		79.6	81.8	91.1	103.8	89.8	125.9	90.9	105.9	97.5
CFM for Max Htg LAT		46	77	67	55	147	47	49	29	44
Reheat + Heating (BTU/Hr)	1,211	1,417	1,396	-184	-358	-154	-303	-123	-191	-288

HVAC Load Calculations - CINT Smart Lab - Air Handling Unit 2

Based on 1997 ASHRAE Handbook CLTD/SCL/CLF Method

Project:	HVA2 Heat Calcs - No lab infiltration, All LED Lights
Project No.:	
Date:	July 10, 2019
Calcs By:	Matney Juntunen
Block or Terminal Loads	

INPUT

General Data

Project Location:	TA-03-1420	
Project Latitude:		deg. N.
Weather Data Source	2017 ASHRAE Handbook of Fundamentals, Chapter 14	
Summer Criteria	1.0	% Occurance
Winter Criteria	99.6	% Occurance
Safety Factor - Cooling	0	%
Safety Factor - Heating	25	%

System Description	Offices and Corridors		
Summer Outside Design Temerature	89	degF	
Inside Summer Design Temperature	78	degF (Default value)	
Summer SA Temperature	55	degF	
Winter Outside Design Temerature	5	degF	
Inside Winter Design Temperature	72	degF (Default value)	
Max. Winter SA Temperature	95	degF	
Min. SA Airflow Percentage	30	%	
Infiltration - Air Change Method	0.25	Air Changes/Hr	Office
Infiltration - Air Leakage Method	0.05	CFM/sf of Wall/Glass surface	Conference
People - Sensible Heat	250	BTU/Hr/ Person	Min. Ventilation
People - Latent Heat	200	BTU/Hr/ Person	Hall/Corridor

Room Data	**Room Description**	Hall	Hall/Corridor	Hall	Hall	Hall & Student Area (4 dt, 4 ppl)	Hall
Room No.:		2000	2100/2100B	2100A	2200	2300/2300A	2000A
Room Name:							
Peak Cooling Month		7	7	7	7	7	7
Peak Cooling Time		1400	1400	1400	1400	1400	1400
Summer Inside Temp (^{o}F)		78	78	78	78	78	78
Winter Inside Temp (^{o}F)		72	72	72	72	72	72
Safety Factor - Summer (%)		0	0	0	0	0	0
Safety Factor - Winter (%)		25	25	25	25	25	25
Room Width (ft)							
Room Length (ft)							
Room Height (ft)		9	9	9	9	9	9
Room Floor Area (sf)	4,175	689	919	442	846	1,043	236
Room Volume (ft^3)	37,575	6,201	8,271	3,978	7,614	9,387	2,124
Ceiling/Parition 1 - Room Name							
Ceiling/Patition 1 Area (sf)	0						
Parition Summer Temp (^{o}F)							
Parition Winter Temp (^{o}F)							
Parition 2 - Room Name							
Patition 2 Area (sf)	0						
Parition 2 Summer Temp (^{o}F)							
Parition 2 Winter Temp (^{o}F)							
Parition 3 - Room Name							
Patition 3 Area (sf)	0						

Room No.:		2000	2100/2100B	2100A	2200	2300/2300A	2000A
Room Name:							
Parition 3 Summer Temp (^{o}F)							
Parition 3 Winter Temp (^{o}F)							
Roof Net Area (sf)	4,175	689	919	442	846	1,043	236
Skylight Area (sf)	0						
Exposed Floor Area:	0						
Slab Edge Length (ft)	0						
Below Gr Wall Area (sf)	0						
Below Gr. Floor Area (sf)	0						
Wall 1 Direction (N, NE..)							
Wall 1 Net Area (sf)	0						
Fenestration 1 Area (sf)	0						
Fenestration 1 Infilration (cfm)	0						
Door 1 Area (sf)	0						
Door 1 Infiltration (cfm)	0						
Wall 2 Direction (N, NE..)		W					W
Wall 2 Net Area (sf)	0						
Fenestration 2 Area (sf)	426	393.75					32
Fenestration 2 Infilration (cfm)	0						
Door 2 Area (sf)	0						
Door 2 Infiltration (cfm)	0						
Wall 3 Direction (N, NE..)							
Wall 3 Net Area (sf)	0						
Fenestration 3 Area (sf)	0						
Fenestration 3 Infilration (cfm)	0						
Door 3 Area (sf)	0						
Door 3 Infiltration (cfm)	0						
Wall 4 Direction (N, NE..)							
Wall 4 Net Area (sf)	0						
Fenestration 4 Area (sf)	0						
Fenestration 4 Infilration (cfm)	0						
Door 4 Area (sf)	0						
Door 4 Infiltration (cfm)	0						
People Type 1 - BTUH/Per. - Sensible		250	250	250	250	250	250
People Type 1 - BTUH/Per. - latent		200	200	200	200	200	200
No. of People - Type 1		0	3	0	0	4	0
People/1000 sf - Type 1							
People Type 2 - BTUH/Per. - Sensible							
People Type 2 - BTUH/Per. - latent							
No. of People - Type 2							
People/1000 sf - Type 2							
Total No. of People	7	0	3	0	0	4	0
Lights (Watts) -Type 1		285	342	114	190	65	114
LIghts (Watts/sf) - Type 1		0.4	0.4	0.3	0.2	0.1	0.5
% of Lights to Space (0-100%) - Type 1		50.0%	50.0%	50.0%	50.0%	50.0%	50.0%
Lights (Watts) - Type 2		13.0	52.0	152.0		114.0	
LIghts (Watts/sf) - Type 2		0.02	0.1	0.3	0.0	0.1	0.0
% of Lights to Space (0-100%) - Type 2		50.0%	50.0%	50.0%	50.0%	50.0%	50.0%
Tot. Lighting Watts to Space	1,351	298	371	243	190	135	114
Tot.Lighting Watts to Plenum	2,450	298	535	396	423	680	118
Equipment 1 (watts)							
Equipment 1 (BTU/H Sens.)							
Equipment 1 (BTU/H Lat.)							
Equipment 2 (watts)							
Equipment 2 (BTU/H Sens.)							
Equipment 2 (BTU/H Lat.)							
Equipment 3 (watts)							
Equipment 3 (BTU/H Sens.)							
Equipment 3 (BTU/H Lat.)							
Total Equip.(BTU/H Sens.)	0	0	0	0	0	0	0

Room No.:		2000	2100/2100B	2100A	2200	2300/2300A	2000A
Room Name:							
Total Equip.(BTU/H Lat.)	0	0	0	0	0	0	0

Summer U-factor Data

	2000	2100/2100B	2100A	2200	2300/2300A	2000A
Roof	0.0192	0.0192	0.0192	0.0192	0.0192	0.0192
Skylight						
Exposed Floor						
Wall 1						0.0228
Wall 2						
Wall 3						
Wall 4						
Fenestration 1	0.38					0.58
Fenestration 2						0.58
Fenestration 3						
Fenestration 4						
Door 1						
Door 2						
Door 3						
Door 4						
Ceiling/Partition 1						
Partition 2						
Partition 3						

Winter U-factor Data

	2000	2100/2100B	2100A	2200	2300/2300A	2000A
Roof						
Skylight						
Exposed Floor						
Slab Edge (BTU/Hr-F-LF)						
Below Gr. Walls (BTU/Hr-F-SF)						
Below Gr. Floors (BTU/H-SF)						
Wall 1						
Wall 2						
Wall 3						
Wall 4						
Fenestration 1						
Fenestration 2						
Fenestration 3						
Fenestration 4						
Door 1						
Door 2						
Door 3						
Door 4						
Ceiling/Partition 1						
Partition 2						
Partition 3						

CLTD (Cooling Load Temperature Difference) Values

	2000	2100/2100B	2100A	2200	2300/2300A	2000A
Roof	39	39	39	39	39	39
Wall 1						30
Wall 2						
Wall 3						
Wall 4						
Fenestration 1	14					14
Fenestration 2						
Fenestration 3						
Fenestration 4						
Door 1						
Door 2						

Room No.:	2000	2100/2100B	2100A	2200	2300/2300A	2000A
Room Name:						
Door 3						
Door 4						

SC (Solar Coefficient glass) x IAC (shading) Values

Skylight						
Fenestration 1						
Fenestration 2						
Fenestration 3						
Fenestration 4						

SCF (Solar Cooling Load Factor) Values

Skylight						
Fenestration 1	0.89	0.89	0.89	0.89	0.89	0.89
Fenestration 2	0.89	0.89	0.89	0.89	0.89	0.89
Fenestration 3	0.89	0.89	0.89	0.89	0.89	0.89
Fenestration 4	0.89	0.89	0.89	0.89	0.89	0.89

CLF (Cooling Load Factor) Values

People - Type 1	0.89	0.89	0.89	0.89	0.89	0.89
People - Type 2	0.89	0.89	0.89	0.89	0.89	0.89
Lights - Type 1	0.94	0.94	0.94	0.94	0.94	0.94
Lights - Type 2	0.94	0.94	0.94	0.94	0.94	0.94
Equipment 1	0.89	0.89	0.89	0.89	0.89	0.89
Equipment 2	0.89	0.89	0.89	0.89	0.89	0.89
Equipment 3	0.89	0.89	0.89	0.89	0.89	0.89

F_U Use Factors

People - Type 1	1.0	1.0	1.0	1.0	1.0	1.0
People - Type 2	1.0	1.0	1.0	1.0	1.0	1.0
Lights - Type 1	1.0	1.0	1.0	1.0	1.0	1.0
Lights - Type 2	1.0	1.0	1.0	1.0	1.0	1.0
Equipment 1	1.0	1.0	1.0	1.0	1.0	1.0
Equipment 2	1.0	1.0	1.0	1.0	1.0	1.0
Equipment 3	1.0	1.0	1.0	1.0	1.0	1.0

OUTPUT

Cooling Load (Summer - Sensible)

	System Totals						
Roof	3,126	516	688	331	633	781	177
Skylight - Transmission	0	0	0	0	0	0	0
Skylight - Solar	0	0	0	0	0	0	0
Exposed Floor	0	0	0	0	0	0	0
Walls	0	0	0	0	0	0	0
Fenestration - Transmission	0	0	0	0	0	0	0
Fenestration - Solar	0	0	0	0	0	0	0
Doors	0	0	0	0	0	0	0
Ceiling/Parition 1	0	0	0	0	0	0	0
Other Paritions	0	0	0	0	0	0	0
People	1,558	0	668	0	0	890	0
Lights	4,619	955	1,263	853	609	574	365
Equipment	0	0	0	0	0	0	0
Total Heat Load (BTU/Hr)	9,303	1,471	2,619	1,184	1,243	2,245	542
Load with Safety Factor	9,303	1,471	2,619	1,184	1,243	2,245	542
BTU/Hr/SF		2	3	3	1	2	2
Max cfm	380	60	110	50	50	90	20
Min cfm	130	20	30	20	20	30	10
Max cfm/sf	0.1	0.1	0.1	0.1	0.1	0.1	0.1

Room No.:		2000	2100/2100B	2100A	2200	2300/2300A	2000A
Room Name:							
Min cfm/sf	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Cooling Load (Summer - Latent)

People	1,400	0	600	0	0	800	0
Equipment	0	0	0	0	0	0	0
Total	1,400	0	600	0	0	800	0

Heat Loss (Winter)

	System Totals						
Roof	0	0	0	0	0	0	0
Skylight	0	0	0	0	0	0	0
Exposed Floor	0	0	0	0	0	0	0
Slab Edge	0	0	0	0	0	0	0
Below Gr Walls	0	0	0	0	0	0	0
Below Gr Floor	0	0	0	0	0	0	0
Walls	0	0	0	0	0	0	0
Fenestration	0	0	0	0	0	0	0
Doors	0	0	0	0	0	0	0
Ceiling /Partition 1	0	0	0	0	0	0	0
Other Partitions	0	0	0	0	0	0	0
Total Infiltration CFM	157	26	34	17	32	39	9
Infiltration BTU/Hr	-11,329	-1,870	-2,494	-1,199	-2,296	-2,830	-640
Total Heat Loss (BTU/Hr)	-11,329	-1,870	-2,494	-1,199	-2,296	-2,830	-640
Load with Safety Factor	-14,161	-2,337	-3,117	-1,499	-2,870	-3,538	-800
BTU/Hr/SF		-3	-3	-3	-3	-3	-3
LAT for Max cfm		108.1	98.2	99.8	125.1	108.4	109.1
LAT for Min cfm		180.2	168.2	141.4	204.8	181.2	146.1
CFM for Max Htg LAT		94	125	60	116	142	32
Reheat + Heating (BTU/Hr)	-3,694	-610	-813	-391	-749	-923	-209

A.4 AHU HEAT LOAD CALCULATION FACTORS (ASHRAE)

CLTD/SCF/CLF Lookup Tables - CINT

A. Project Data

1. Project Latitude:		35.6	degN (+ values for North latitudes. Use - values for South latitudes)
2. Design Temperatures			
a.	Outside	89	degF maximum
		20	degF average daily range of highest - lowest temperature
b.	Inside	72	degF
3. Wall Construction			
a.	Wall Type	1	See Table 1 below
b.	Siding Type	2	See Table 2 below
c.	R-value	43.888579	hr-sf-oF/BTU
d.	Insulation Location	0	(0=Insulation evenly distributed, 1=Inside of mass, 2=Outside of mass)
4. Roof Construction			
a.	Roof Type #	52.083333	(1=steel deck+insulation, 2 = 1"wood deck + insulation, 3= 2" or more of concrete deck + insulation)
b.	R-value	20	hr-sf-oF/BTU
c.	Insulation Location	1	(1 = Inside of deck, 2=Outside of deck)
d.	Suspended Ceiling?	Y	(Y=Yes, N= No)
e.	Attic?	Y	(Y=Yes, N= No)
5. Interior Construction			
a.	Carpet?	Y	(Y/N) N= vinyl flooring or bare concrete floors
b.	Partition Type	1	1 = Gypsum board, 2 = concrete block
c.	Inside Shades?	N	(Y/N)
d.	Small or large zones at perimeter	2	1 = Small (<200 sf) , 2 = large, >200 sf
e.	Multiple stories?	Y	(Y/N)
f.	Floor Type	1	1 = concrete (cast-in-place or concrete on metal decking, 2 = wood framed floors)
6. Building Schedules			
a.	People	10	hours/day - average
b.	Lights	8	hours/day - average
c.	Equipment	10	hours/day - average

TABLE 1 - Wall Types

Wall Type #	Lbs/SF	ASHRAE #	General Description
1	3.1	B7	1" wood, metal framed
2	6.2	B10	2" wood, wood framed
3	9.7	A1	1" Stucco
4	12.0	C17	8" LW concrete block - filled
5	12.3	B9	4" wood
6	12.7	C2	4" LW concrete
7	20.3	C3	4" HW concrete
8	23.3	C1	4" clay tile
9	35.4	C18	8" HW concrete block - filled
10	40.0	C4	4" common brick
11	40.7	C7	8" LW concrete block
12	41.7	A2	4" face brick
13	46.7	C5	4" HW concrete
14	46.7	C6	8" clay tile
15	93.4	C8	8" HW concrete block

TABLE 2 - Siding Types (Outside Surface)

Siding Type #	Lbs/SF		General Description
1	1	LW	Light weight - Siding (steel, wood)
2	9.7	SP	Medium weight - Stucco or Plaster
3	41.7	FB	Heavy Weight - Face Brick, precast

Notes -

1 Data taken from 1997 ASHRAE Handbook of Fundamentals, Chapter 18 for CLTD, SCF, and CLF.

Wall CLTD Values - CINT□

Correction Factor applied to table = 0 degF

Search Criteria					
ASHRAE Wall No.	Wall Type	Siding Type	Insulation Location	Max R-Value	Latitude
4	B7	SP	Even	27	32

Wall CLTD Values

Wall Direction	July 21st Hour											
	9	10	11	12	13	14	15	16	17	18	19	20
N	3	5	7	10	14	17	20	24	29	26	27	27
NE	14	35	39	34	34	33	32	30	29	29	28	26
E	15	27	39	46	51	48	45	40	36	34	32	29
SE	7	15	23	29	42	46	47	44	39	37	34	30
S	0	1	4	10	15	21	26	39	41	42	39	35
SW	1	2	5	6	10	16	22	33	42	53	57	57
W	1	2	5	8	11	15	21	30	39	51	60	64
NW	0	2	4	8	15	25	22	25	31	37	45	49

Wall CLTD Values

Wall Direction	October 21st Hour											
	9	10	11	12	13	14	15	16	17	18	19	20
N	2	4	6	8	10	12	14	13	8	7	7	7
NE	6	13	22	26	26	24	23	19	12	7	7	7
E	15	27	36	36	39	36	43	25	15	9	8	7
SE	10	23	39	60	75	42	35	28	16	9	9	8
S	0	4	11	22	35	54	81	103	48	11	10	9
SW	1	2	9	13	17	24	35	44	35	13	14	14
W	1	2	4	6	10	15	21	28	24	13	15	16
NW	0	2	3	6	8	9	9	13	13	9	11	12

Notes

CLTD corrected = (78-T inside) + (T oa design - daily range/2)-85)

Correcetd for latitude

Data from 1997 ASHRAE Handbook of Fundamentals, Chapter 28, Tables 32 and 33A, 33B, 33C.

Roof CLTD Values - CINT

Correction Factor applied to table = 0 degF

Search Criteria					
ASHRAE Roof No.	Mass Location	Suspended Celing	Max R-Value	Roof Description	Latitude
14	Mass Inside Insulation	With	25	2" HW Concrete	32

Roof CLTD Values for Selected Roof Type

Month	9	10	11	12	13	14	15	16	17	18	19	20
July 21st	19	21	23	25	29	33	37	39	39	44	45	45
Oct. 21st	14	16	19	21	24	26	26	22	14	11	11	11

Notes

CLTD corrected = (78-T inside) + (T oa design - daily range/2)-85)
Corrected for latitude
Data from 1997 ASHRAE Handbook of Fundamentals, Chapter 28, Tables 30 and 31.

Glass CLTD Values - CINT□

Correction Factor applied to table = 0 degF

Glass CLTD Values												
Wall Direction	Hour											
	9	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
All	2	4	7	9	12	13	14	14	13	12	10	8

Notes
CLTD corrected = (78-T inside) + (T oa design - daily range/2)-85)
Data from 1997 ASHRAE Handbook of Fundamentals, Chapter 28, Table 34.

Glass SCL Values - CINT

Search Criteria					
ASHRAE Zone Type	Zone Size	Flooring	Partition Type	Inside Shading	Latitude
A	Large	Carpet	Gypsum	N	32

Glass SCL Values

Wall Direction	July 21st Hour											
	9	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
N	34	37	40	42	42	41	38	35	39	36	12	6
NE	136	139	80	52	46	41	38	32	25	18	7	3
E	185	156	109	69	56	46	40	33	25	18	7	3
SE	114	126	102	70	60	49	42	34	26	18	7	3
S	27	42	55	64	62	55	41	39	30	20	8	4
SW	31	35	36	29	51	96	120	169	172	156	57	27
W	31	36	40	41	67	116	160	188	186	156	57	27
NW	31	36	40	43	58	93	102	133	147	130	46	22
Horizontal	172	219	251	268	270	255	221	176	115	70	29	14

Glass SCL Values

Wall Direction	October 21st Hour											
	9	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
N	20	24	28	29	29	27	23	14	4	0	0	0
NE	35	35	37	35	32	27	24	16	5	0	0	0
E	183	155	99	49	39	31	38	17	5	0	0	0
SE	211	221	209	183	125	44	28	17	5	0	0	0
S	114	145	173	191	195	190	174	126	35	0	0	0
SW	20	31	75	76	104	168	222	241	129	0	0	0
W	29	24	28	29	61	115	158	170	87	0	0	0
NW	19	24	28	29	27	23	26	52	38	0	0	0
Horizontal	109	158	193	209	207	183	140	76	14	0	0	0

Notes

Data from 1997 ASHRAE Handbook of Fundamentals, Chapter 28, Tables 35A, 35B, and 36.
Data corrected for latitude and Month based on SHGF in 1997 ASHRAE Handbook of Findamentals, Chapter 29

PEOPLE AND UNHOODED EQUIPMENT CFL VALUES - CINT□

Search Criteria				
ASHRAE Zone Type	Zone Size	Flooring	Partition Type	Inside Shading
B	Large	Carpet	Gypsum	N

People CLF Values

Hours in Space	Hour after entry											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
10	0.65	0.75	0.81	0.85	0.89	0.91	0.93	0.95	0.96	0.97	0.33	0.24

Unhooded Equipment CLF Values

Hours of Operation	Hour after start											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
10	0.65	0.75	0.81	0.85	0.89	0.91	0.93	0.95	0.96	0.97	0.33	0.24

Notes

Data from 1997 ASHRAE Handbook of Fundamentals, Chapter 28, Tables 35A, 35B, and 37.

HOODED EQUIPMENT CFL VALUES - CINT

Search Criteria				
ASHRAE Zone Type	Zone Size	Flooring	Partition Type	Inside Shading
B	Large	Carpet	Gypsum	N

Hooded Equipment CLF Values												
Hours of Operation	Hour after start											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
10	0.5	0.64	0.73	0.79	0.84	0.87	0.9	0.93	0.94	0.96	0.47	0.34

Notes

Data from 1997 ASHRAE Handbook of Fundamentals, Chapter 28, Tables 35A, 35B, and 39.

LIGHTING CFL VALUES - CINT□

Search Criteria				
ASHRAE Zone Type	Zone Size	Flooring	Partition Type	Inside Shading
B	Large	Carpet	Gypsum	N

Lighting CLF Values												
	Hour After Lights Turned On.											
Hr/Day On	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
8	0.75	0.85	0.9	0.93	0.94	0.95	0.95	0.96	0.23	0.12	0.08	0.05

Notes

Data from 1997 ASHRAE Handbook of Fundamentals, Chapter 28, Tables 35A, 35B, and 38.

Glass U-factor Adjustments - CINT

Project:	CINT HVA2 Heat Calcs
Project No.:	
Date:	7/9/2019
Calcs By:	Matney Juntunen
Description	

INPUT DATA

Frame Outside Dimension

Total Length	48	Inches
Total Height	48	Inches
Width of frame element	2	Inches
No. of horizontal panes	1	
No. of vertical panes	1	

U-Factors

U center of glass	0.3	BTU/Hr-sf-^oF
U frame	1.32	BTU/Hr-sf-^oF

OUTPUT DATA

Area of frame	384	sq. in.	16.7%
Area of edge glass	480	sq. in.	20.8%
Area of center of glass	1440	sq. in.	62.5%
Area - total of glass + frame	2304	sq. in.	100.0%
U-factor edge of glass	0.81	BTU/Hr-sf-^oF	
U-factor total adjusted	**0.58**	**BTU/Hr-sf-^oF**	

Wall U-factor Calculations - HVA1

Project:	03-1420 Smart Lab - HVAC Calculations for HVA1
Project No.:	
Date:	Summer 2019
Calcs By:	Matney Juntunen

Wall 1 Description: Laboratory Walls

Thickness (Inches)	**Item**	**Reference**	**k-factor BTU-in/Hr-sf-F**	**Density Lbs/ft3**	**Summer R - Value**	**Winter R - Value**	**Mass (lbs/sf)**
-	Outside Air Film	2017 ASHRAE F26.			0.25	0.17	0.0
	Wood Siding		0.375	22	-	-	0.0
	Face Brick		4.55	50	-	-	0.0
	Precast Concrete		3.3	80	-	-	0.0
	Stucco		0.55	25	-	-	0.0
	Concrete Block (4, 8, or 12")		4.71	55	-	-	0.0
	Filled Concrete Block (6,8,or12")		4.71	56	-	-	0.0
	Concrete		9.0	140	-	-	0.0
	Clay Tile (3,4,6,8,10, or 12")		3.6	40	-	-	0.0
	Glass Spandrel Panels (1")		1.7	39.5	-	-	0.0
	Air Space				0.00	0.00	0.0
	Plywood		0.63	34	-	-	0.0
	Gypsum Board		1.1	40	-	-	0.0
	Extruded Polystyrene R-5/in		0.2	1.4	-	-	0.0
	Expanded Polystyrene R-4/in		0.25	1.0	-	-	0.0
	Cellar Polyurethane R-6.25/in		0.16	1.9	-	-	0.0
	Polyisocyanurate R-7.04/in		0.14	1.6	-	-	0.0
	Air Space				0.00	0.00	0
	Fiberglass Batt & Wood Studs		0.40	3.79	-	-	0.0
	Fiberglass Batt & Metal Studs		0.37	2.74	-	-	0.0
	Plywood or Hardboard		0.63	34	-	-	0.0
	Gypsum Board		1.1	40	-	-	0.0
	Gypsum Plaster		0.55	70	-	-	0.0
-	Inside Air Film				0.68	0.68	0.0
Total R-Value =					**0.93**	**0.85**	
U-Factor = 1/R =					**1.08**	**1.18**	
Wall Mass (lbs/sf)							0.0

Roof U-factor Calculations - HVA1

Project:	03-1420 Smart Lab - HVAC Calculations for HVA1
Project No.:	
Date:	Summer 2019
Calcs By:	Matney Juntunen

Roof 1 Description

Thickness (Inches)	Item	Reference	k-factor BTU-in/Hr-sf-F	Nom. Density Lbs/ft3	Summer R - Value	Winter R - Value	Mass (lbs/sf)
-	Outside Air Film	2017 ASHRAE F26.		0.057	0.25	0.17	0.0
	Wood Shingles (Up to 3/8")		0.375	22	-	-	0.0
	Asphalt Shingles (1/8")		2.98	100	-	-	0.0
	Ballast/Membrane Roof (0.1")		8.33	60	-	-	0.0
	Slate (Up to 1/2")		10	150	-	-	0.0
	Built-up Roofing (3/8")		1.14	70	-	-	0.0
0.1	Metal Deck (0.1")		314.4	489	0.00	0.00	4.1
	Precast Concrete Planks(8 or10")		4.71	55	-	-	0.0
	Concrete		9.0	140	-	-	0.0
0.6	Plywood		0.63	34	0.99	0.99	1.8
	Gypsum Board		1.1	40	-	-	0.0
	Extruded Polystyrene R-5/in		0.2	1.4	-	-	0.0
	Expanded Polystyrene R-4/in		0.25	1.0	-	-	0.0
	Cellar Polyurethane R-6.25/in		0.16	1.9	-	-	0.0
6.3	Polyisocyanurate R-7.04/in		0.14	1.6	44.00	44.00	0.8
110.4	Air Space			0.057	1.44	0.77	0.0
	Fiberglass Batt		0.3158	1.8	-	-	0.0
	Air Space			0.057	0.00	0.00	0.0
	Plywood or Hardboard		0.63	34	-	-	0.0
	Gypsum Board		1.1	40	-	-	0.0
	Gypsum Plaster		0.55	70	-	-	0.0
2.00	Acoustical Tile		0.36	21	5.56	5.56	3.5
-	Inside Air Film			0.057	0.92	0.61	0.0
Total R-Value =					**53.15**	**52.09**	
U-Factor = 1/R =					**0.0188**	**0.0192**	
Roof Mass (lbs/sf)							10.2

Roof U-factor Calculations - HVA1

Project:	03-1420 Smart Lab - HVAC Calculations for HVA1
Project No.:	
Date:	Summer 2019
Calcs By:	Matney Juntunen

Roof 1 Description

Thickness (Inches)	**Item**	**Reference**	**k-factor** BTU-in/Hr-sf-F	**Nom. Densit** Lbs/ft3	**Summer** R - Value	**Winter** R - Value	**Mass** (lbs/sf)
-	Outside Air Film	2017 ASHRAE F26.		0.057	0.25	0.17	0.0
	Wood Shingles (Up to 3/8")		0.375	22	-	-	0.0
	Asphalt Shingles (1/8")		2.98	100	-	-	0.0
	Ballast/Membrane Roof (0.1")		8.33	60	-	-	0.0
	Slate (Up to 1/2")		10	150	-	-	0.0
	Built-up Roofing (3/8")		1.14	70	-	-	0.0
0.1	Metal Deck (0.1")		314.4	489	0.00	0.00	4.1
	Precast Concrete Planks(8 or10")		4.71	55	-	-	0.0
	Concrete		9.0	140	-	-	0.0
0.6	Plywood		0.63	34	0.99	0.99	1.8
	Gypsum Board		1.1	40	-	-	0.0
	Extruded Polystyrene R-5/in		0.2	1.4	-	-	0.0
	Expanded Polystyrene R-4/in		0.25	1.0	-	-	0.0
	Cellar Polyurethane R-6.25/in		0.16	1.9	-	-	0.0
6.3	Polyisocyanurate R-7.04/in		0.14	1.6	44.00	44.00	0.8
138.0	Air Space			0.057	1.44	0.77	0.0
	Fiberglass Batt		0.3158	1.8	-	-	0.0
	Air Space			0.057	0.00	0.00	0.0
	Plywood or Hardboard		0.63	34	-	-	0.0
	Gypsum Board		1.1	40	-	-	0.0
	Gypsum Plaster		0.55	70	-	-	0.0
2.00	Acoustical Tile		0.36	21	5.56	5.56	3.5
-	Inside Air Film			0.057	0.92	0.61	0.0
Total R-Value =					**53.15**	**52.09**	
U-Factor = 1/R =					**0.0188**	**0.0192**	
Roof Mass (lbs/sf)							10.2

Floor U-factor Calculations - HVA1

Project:	03-1420 Smart Lab - HVAC Calculations for HVA1
Project No.:	
Date:	Summer 2019
Calcs By:	Matney Juntunen

Floor 1 Description

Thickness (Inches)	Item	Reference	k-factor BTU-in/Hr-sf-F	Density Lbs/ft3	Summer R - Value	Winter R - Value	Mass (lbs/sf)
I	Inside/Outside Air Film (I or O)	2017 ASHRAE F26.			0.61	0.92	0.0
	Precast Concrete Planks(8 or10")		4.71	55	-	-	0.0
	Concrete		9.0	140	-	-	0.0
	Metal Deck (0.1")		314.4	489	-	-	0.0
	Plywood		0.63	34	-	-	0.0
	Gypsum Board		1.1	40	-	-	0.0
	Extruded Polystyrene R-5/in		0.2	1.4	-	-	0.0
	Expanded Polystyrene R-4/in		0.25	1.0	-	-	0.0
	Cellar Polyurethane R-6.25/in		0.16	1.9	-	-	0.0
	Polyisocyanurate R-7.04/in		0.14	1.6	-	-	0.0
	Air Space				0.00	0.00	0.0
	Fiberglass Batt		0.3158	1.8	0.00	0.00	0.0
	Air Space				0.00	0.00	0.0
	Precast Concrete Planks(8 or10")		4.71	55	-	-	0.0
	Concrete		9.0	140	-	-	0.0
	Plywood		0.63	34	-	-	0.0
	Carpeting (3/8")		0.55	20	-	-	0.0
	Terazzo (1")		12.50	120	-	-	0.0
	Tile -Linoleum/cork (1/4")		0.49	29	-	-	0.0
-	Inside Air Film				0.61	0.92	0.0
Total R-Value =					**1.22**	**1.84**	
U-Factor = 1/R =					**0.82**	**0.54**	
Floor Mass (lbs/sf)							0.0

Ceiling Partition U-factor Calculations - HVA1

Project:	03-1420 Smart Lab - HVAC Calculations for HVA1
Project No.:	
Date:	Summer 2019
Calcs By:	Matney Juntunen

Partition 1 Description

Thickness (Inches)	Item	Reference	k-factor BTU-in/Hr-sf-F	Density Lbs/ft3	Summer R - Value	Winter R - Value	Mass (lbs/sf)
-	Inside Air Film	2017 ASHRAE F26.			0.92	0.61	0.0
	Precast Concrete		3.3	80	-	-	0.0
	Concrete		9.0	140	-	-	0.0
	Plywood		0.63	34	-	-	0.0
	Gypsum Board		1.1	40	-	-	0.0
	Air Space				0.00	0.00	0
	Fiberglass Batt & Wood Studs		0.40	3.79	-	-	0.0
	Fiberglass Batt & Metal Studs		0.37	2.74	-	-	0.0
	Plywood or Hardboard		0.63	34	-	-	0.0
	Gypsum Board		1.1	40	-	-	0.0
	Gypsum Plaster		0.55	70	-	-	0.0
	Acoustical Tile		0.36	21	-	-	0.0
-	Inside Air Film				0.92	0.61	0.0
Total R-Value =					**1.84**	**1.22**	
U-Factor = 1/R =					**0.54**	**0.82**	
Partition Mass (lbs/sf)							0.0

Roof U-factor Calculations - HVA2

Project:	03-1420 Smart Lab - HVAC Calculations for HVA2
Project No.:	
Date:	Summer 2019
Calcs By:	Matney Juntunen

Roof 1 Description

Thickness (Inches)	Item	Reference	k-factor BTU-in/Hr-sf-F	Nom. Densit Lbs/ft3	Summer R - Value	Winter R - Value	Mass (lbs/sf)
-	Outside Air Film	2017 ASHRAE F26.		0.057	0.25	0.17	0.0
	Wood Shingles (Up to 3/8")		0.375	22	-	-	0.0
	Asphalt Shingles (1/8")		2.98	100	-	-	0.0
	Ballast/Membrane Roof (0.1")		8.33	60	-	-	0.0
	Slate (Up to 1/2")		10	150	-	-	0.0
	Built-up Roofing (3/8")		1.14	70	-	-	0.0
0.1	Metal Deck (0.1")		314.4	489	0.00	0.00	5.1
	Precast Concrete Planks(8 or10")		4.71	55	-	-	0.0
	Concrete		9.0	140	-	-	0.0
0.5	Plywood		0.63	34	0.79	0.79	1.4
	Gypsum Board		1.1	40	-	-	0.0
	Extruded Polystyrene R-5/in		0.2	1.4	-	-	0.0
	Expanded Polystyrene R-4/in		0.25	1.0	-	-	0.0
	Cellar Polyurethane R-6.25/in		0.16	1.9	-	-	0.0
5.88	Polyisocyanurate R-7.04/in		0.14	1.6	41.36	41.36	0.8
	Air Space			0.057	0.00	0.00	0.0
	Fiberglass Batt		0.3158	1.8	-	-	0.0
	Air Space			0.057	0.00	0.00	0.0
	Plywood or Hardboard		0.63	34	-	-	0.0
0.6	Gypsum Board		1.1	40	0.57	0.57	2.1
	Gypsum Plaster		0.55	70	-	-	0.0
	Acoustical Tile		0.36	21	-	-	0.0
-	Inside Air Film			0.057	0.92	0.61	0.0
Total R-Value =					**43.89**	**43.50**	
U-Factor = 1/R =					**0.0228**	**0.0230**	
Roof Mass (lbs/sf)							9.4

Roof U-factor Calculations - HVA2

Project:	03-1420 Smart Lab - HVAC Calculations for HVA2
Project No.:	
Date:	Summer 2019
Calcs By:	Matney Juntunen

Roof 1 Description

Thickness (Inches)	Item	Reference	k-factor BTU-in/Hr-sf-F	Nom. Densit Lbs/ft3	Summer R - Value	Winter R - Value	Mass (lbs/sf)
-	Outside Air Film	2017 ASHRAE F26.		0.057	0.25	0.17	0.0
	Wood Shingles (Up to 3/8")		0.375	22	-	-	0.0
	Asphalt Shingles (1/8")		2.98	100	-	-	0.0
	Ballast/Membrane Roof (0.1")		8.33	60	-	-	0.0
	Slate (Up to 1/2")		10	150	-	-	0.0
	Built-up Roofing (3/8")		1.14	70	-	-	0.0
0.1	Metal Deck (0.1")		314.4	489	0.00	0.00	4.1
	Precast Concrete Planks(8 or10")		4.71	55	-	-	0.0
	Concrete		9.0	140	-	-	0.0
0.6	Plywood		0.63	34	0.99	0.99	1.8
	Gypsum Board		1.1	40	-	-	0.0
	Extruded Polystyrene R-5/in		0.2	1.4	-	-	0.0
	Expanded Polystyrene R-4/in		0.25	1.0	-	-	0.0
	Cellar Polyurethane R-6.25/in		0.16	1.9	-	-	0.0
6.3	Polyisocyanurate R-7.04/in		0.14	1.6	44.00	44.00	0.8
110.4	Air Space			0.057	1.44	0.77	0.0
	Fiberglass Batt		0.3158	1.8	-	-	0.0
	Air Space			0.057	0.00	0.00	0.0
	Plywood or Hardboard		0.63	34	-	-	0.0
	Gypsum Board		1.1	40	-	-	0.0
	Gypsum Plaster		0.55	70	-	-	0.0
2.00	Acoustical Tile		0.36	21	5.56	5.56	3.5
-	Inside Air Film			0.057	0.92	0.61	0.0
Total R-Value =					**53.15**	**52.09**	
U-Factor = 1/R =					**0.0188**	**0.0192**	
Roof Mass (lbs/sf)							10.2

Roof U-factor Calculations - HVA2

Project:	03-1420 Smart Lab - HVAC Calculations for HVA2
Project No.:	
Date:	Summer 2019
Calcs By:	Matney Juntunen

Roof 1 Description

Thickness (Inches)	**Item**	**Reference**	**k-factor** BTU-in/Hr-sf-F	**Nom. Densit** Lbs/ft3	**Summer R - Value**	**Winter R - Value**	**Mass (lbs/sf)**
-	Outside Air Film	2017 ASHRAE F26.		0.057	0.25	0.17	0.0
	Wood Shingles (Up to 3/8")		0.375	22	-	-	0.0
	Asphalt Shingles (1/8")		2.98	100	-	-	0.0
	Ballast/Membrane Roof (0.1")		8.33	60	-	-	0.0
	Slate (Up to 1/2")		10	150	-	-	0.0
	Built-up Roofing (3/8")		1.14	70	-	-	0.0
0.1	Metal Deck (0.1")		314.4	489	0.00	0.00	4.1
	Precast Concrete Planks(8 or10")		4.71	55	-	-	0.0
	Concrete		9.0	140	-	-	0.0
0.6	Plywood		0.63	34	0.99	0.99	1.8
	Gypsum Board		1.1	40	-	-	0.0
	Extruded Polystyrene R-5/in		0.2	1.4	-	-	0.0
	Expanded Polystyrene R-4/in		0.25	1.0	-	-	0.0
	Cellar Polyurethane R-6.25/in		0.16	1.9	-	-	0.0
6.3	Polyisocyanurate R-7.04/in		0.14	1.6	44.00	44.00	0.8
138.0	Air Space			0.057	1.44	0.77	0.0
	Fiberglass Batt		0.3158	1.8	-	-	0.0
	Air Space			0.057	0.00	0.00	0.0
	Plywood or Hardboard		0.63	34	-	-	0.0
	Gypsum Board		1.1	40	-	-	0.0
	Gypsum Plaster		0.55	70	-	-	0.0
2.00	Acoustical Tile		0.36	21	5.56	5.56	3.5
-	Inside Air Film			0.057	0.92	0.61	0.0
Total R-Value =					**53.15**	**52.09**	
U-Factor = 1/R =					**0.0188**	**0.0192**	
Roof Mass (lbs/sf)							10.2

Floor U-factor Calculations - HVA2

Project:	03-1420 Smart Lab - HVAC Calculations for HVA2
Project No.:	
Date:	Summer 2019
Calcs By:	Matney Juntunen

Floor 1 Description Offices and Corridors

Thickness (Inches)	Item	Reference	k-factor BTU-in/Hr-sf-F	Density Lbs/ft3	Summer R - Value	Winter R - Value	Mass (lbs/sf)
I	Inside/Outside Air Film (I or O)	2017 ASHRAE F26.		0.057	0.61	0.92	0.0
	Precast Concrete Planks(8 or10")		4.71	55	-	-	0.0
	Concrete		9.0	140	-	-	0.0
	Metal Deck (0.1")		314.4	489	-	-	0.0
	Plywood		0.63	34	-	-	0.0
	Gypsum Board		1.1	40	-	-	0.0
	Extruded Polystyrene R-5/in		0.2	1.4	-	-	0.0
	Expanded Polystyrene R-4/in		0.25	1.0	-	-	0.0
	Cellar Polyurethane R-6.25/in		0.16	1.9	-	-	0.0
	Polyisocyanurate R-7.04/in		0.14	1.6	-	-	0.0
	Air Space				0.00	0.00	0.0
	Fiberglass Batt		0.3158	1.8	0.00	0.00	0.0
	Air Space				0.00	0.00	0.0
	Precast Concrete Planks(8 or10")		4.71	55	-	-	0.0
6.0	Concrete		9.0	140	0.67	0.67	70.0
	Plywood		0.63	34	-	-	0.0
	Carpeting (3/8")		0.55	20	-	-	0.0
	Terazzo (1")		12.50	120	-	-	0.0
	Tile -Linoleum/cork (1/4")		0.49	29	-	-	0.0
-	Inside Air Film				0.61	0.92	0.0
Total R-Value =					**1.89**	**2.51**	
U-Factor = 1/R =					**0.53**	**0.40**	
Floor Mass (lbs/sf)							70.0

Floor U-factor Calculations - HVA2

Project:	03-1420 Smart Lab - HVAC Calculations for HVA2
Project No.:	
Date:	Summer 2019
Calcs By:	Matney Juntunen

Floor 1 Description: Offices and Corridors

Thickness (Inches)	Item	Reference	k-factor BTU-in/Hr-sf-F	Density Lbs/ft3	Summer R - Value	Winter R - Value	Mass (lbs/sf)
I	Inside/Outside Air Film (I or O)	2017 ASHRAE F26.		0.057	0.61	0.92	0.0
	Precast Concrete Planks(8 or10")		4.71	55	-	-	0.0
	Concrete		9.0	140	-	-	0.0
	Metal Deck (0.1")		314.4	489	-	-	0.0
	Plywood		0.63	34	-	-	0.0
	Gypsum Board		1.1	40	-	-	0.0
	Extruded Polystyrene R-5/in		0.2	1.4	-	-	0.0
	Expanded Polystyrene R-4/in		0.25	1.0	-	-	0.0
	Cellar Polyurethane R-6.25/in		0.16	1.9	-	-	0.0
	Polyisocyanurate R-7.04/in		0.14	1.6	-	-	0.0
	Air Space				0.00	0.00	0.0
	Fiberglass Batt		0.3158	1.8	0.00	0.00	0.0
	Air Space				0.00	0.00	0.0
	Precast Concrete Planks(8 or10")		4.71	55	-	-	0.0
6.0	Concrete		9.0	140	0.67	0.67	70.0
	Plywood		0.63	34	-	-	0.0
0.4	Carpeting (3/8")		0.55	20	0.68	0.68	0.6
	Terazzo (1")		12.50	120	-	-	0.0
	Tile -Linoleum/cork (1/4")		0.49	29	-	-	0.0
-	Inside Air Film				0.61	0.92	0.0
Total R-Value =					**2.57**	**3.19**	
U-Factor = 1/R =					**0.39**	**0.31**	
Floor Mass (lbs/sf)							70.6

Ceiling Partition U-factor Calculations - HVA2

Project:	03-1420 Smart Lab - HVAC Calculations for HVA2
Project No.:	
Date:	Summer 2019
Calcs By:	Matney Juntunen

Partition 1 Description

Thickness (Inches)	Item	Reference	k-factor BTU-in/Hr-sf-F	Density Lbs/ft3	Summer R - Value	Winter R - Value	Mass (lbs/sf)
-	Inside Air Film	2017 ASHRAE F26.			0.92	0.61	0.0
	Precast Concrete		3.3	80	-	-	0.0
	Concrete		9.0	140	-	-	0.0
	Plywood		0.63	34	-	-	0.0
	Gypsum Board		1.1	40	-	-	0.0
	Air Space				0.00	0.00	0
	Fiberglass Batt & Wood Studs		0.40	3.79	-	-	0.0
	Fiberglass Batt & Metal Studs		0.37	2.74	-	-	0.0
	Plywood or Hardboard		0.63	34	-	-	0.0
	Gypsum Board		1.1	40	-	-	0.0
	Gypsum Plaster		0.55	70	-	-	0.0
	Acoustical Tile		0.36	21	-	-	0.0
-	Inside Air Film				0.92	0.61	0.0
Total R-Value =					**1.84**	**1.22**	
U-Factor = 1/R =					**0.54**	**0.82**	
Partition Mass (lbs/sf)							0.0

A.5 WEEKLY TEAM PRESENTATION (7/24/19)

ALDCP Student Team 7/25/19 Briefing

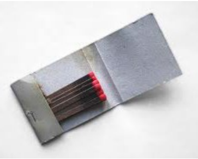
Week 7 Briefing
Matney Juntunen
July 25th, 2019

UNCLASSIFIED

Managed by Triad National Security, LLC for the U.S. Department of Energy's NNSA

LA-UR-19-27499

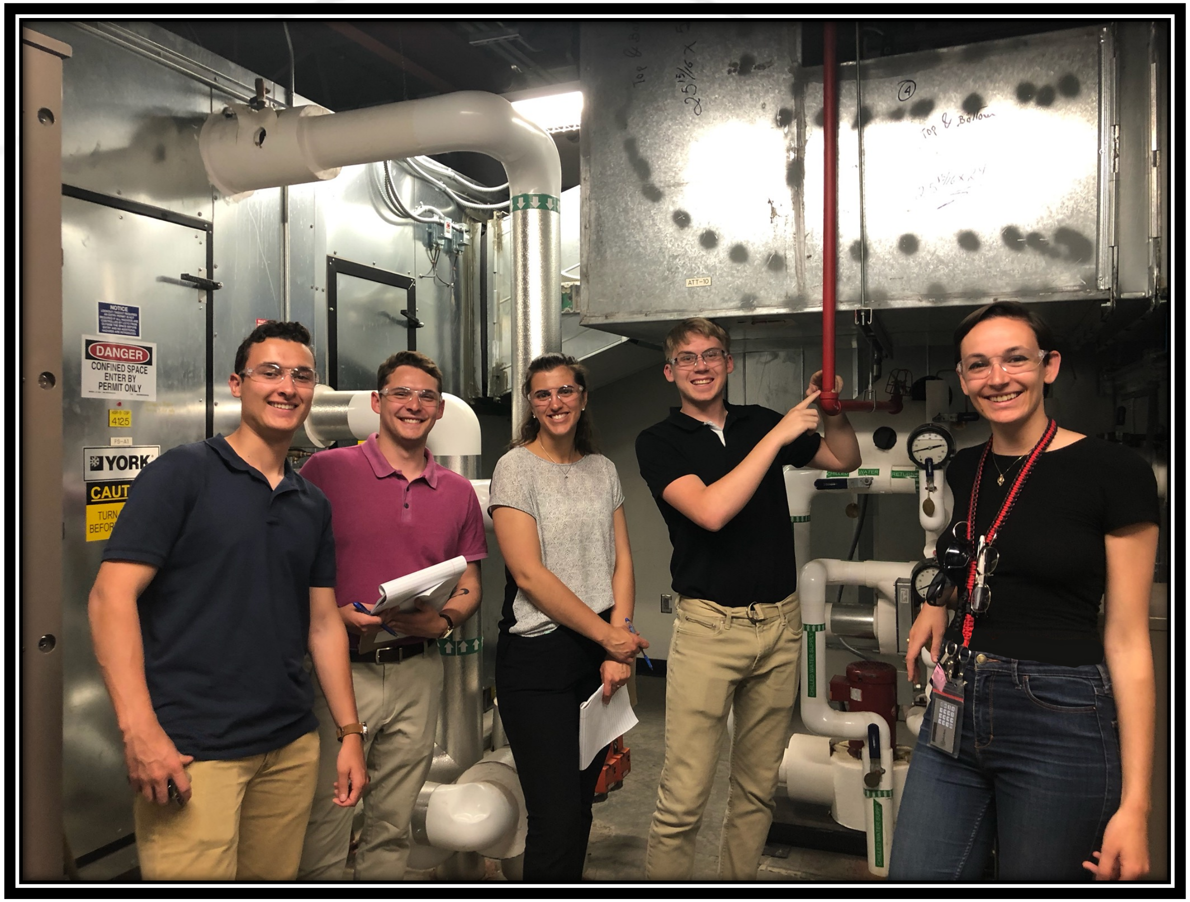
Survival situations are rare, unexpected, and deadly.



Don't let your mamas be worried:

- Tell someone <u>exactly</u> where you are going and when you will be back
- Bring a map/GPS device
- Practice with your equipment!
- Bring water, food, and proper weather gear

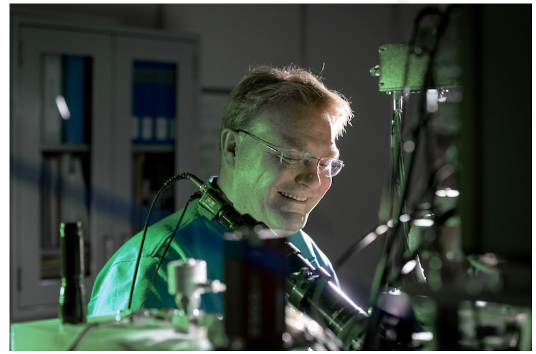
Always follow proper cautionary guidelines when out in the wilderness.

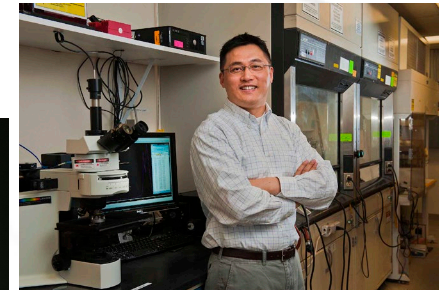


Better Buildings®
U.S. DEPARTMENT OF ENERGY

WHAT IS A SMART LAB?

	SMART LAB KEY COMPONENTS
1	Fundamental platform of dynamic, digital control systems
2	Demand-based ventilation
3	Exhaust fan discharge velocity optimization
4	Pressure drop optimization
5	Fume hood flow optimization
6	Low power density, demand based lighting
7	Commissioning with automated cross platform fault detection





Better Buildings®
U.S. DEPARTMENT OF ENERGY

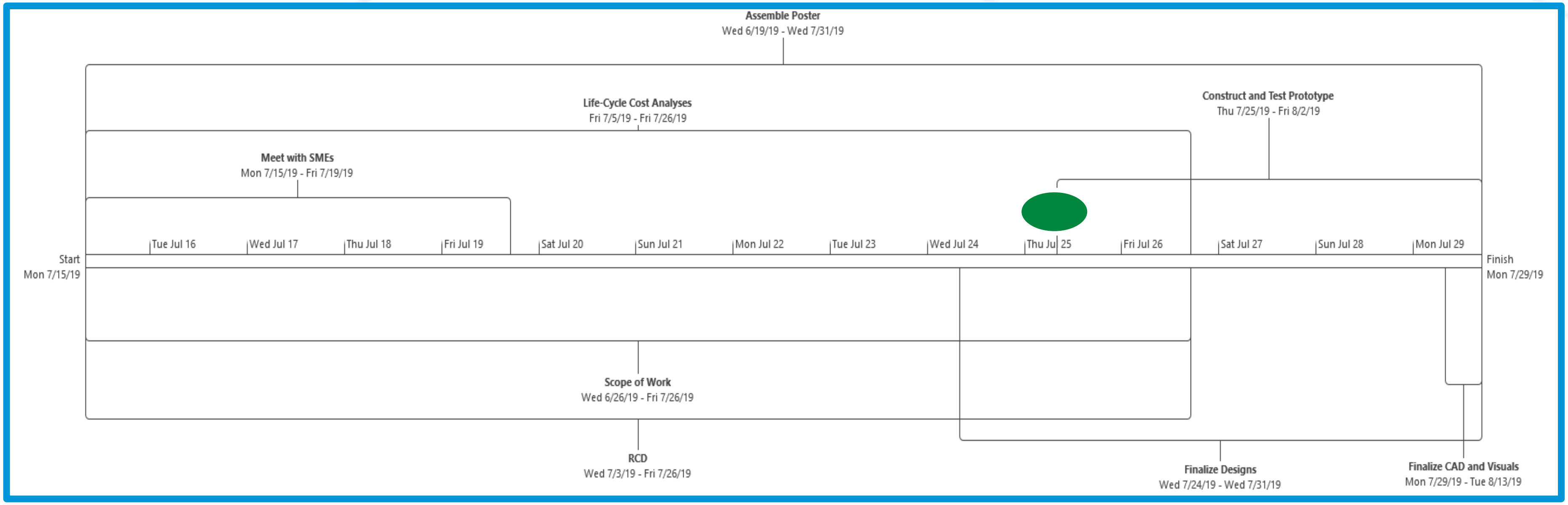
Smart Labs reduce energy demands for laboratories.

TA 03-1420

- **Generate an optimized Smart Lab design package to reduce CINT energy demand and increase overall health, safety, and productiveness.**

We are aiding the implementation of the Smart Lab initiative at LANL.

SCHEDULE



The end is near!

NNSA National Nuclear Security Administration

Los Alamos NATIONAL LABORATORY EST. 1943

ACCOMPLISHMENTS AND BARRIERS

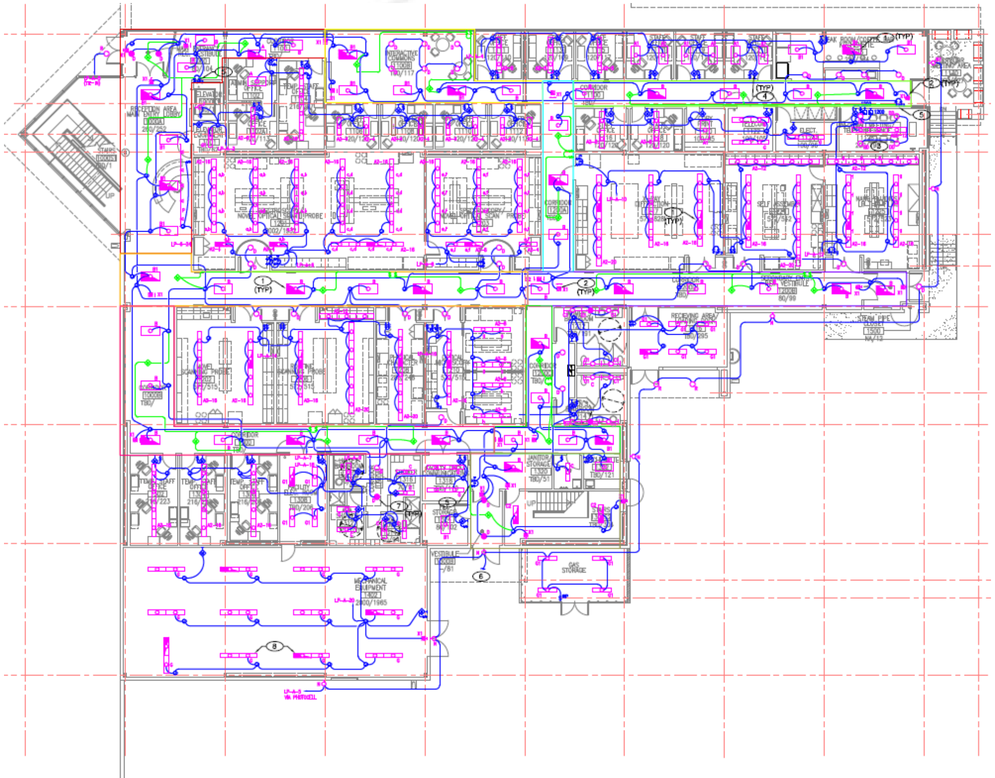
- Design package for lab airflow optimization
- Energy recovery system (ERS) design and estimation
- Began prototype construction/testing
- Poster and visuals 90% complete
- Class 4 total project estimation
- Continuing life-cycle cost analyses

BARRIERS

- Outside communication
- Prototype construction delay
- Door sealing test canceled

Project is close towards finalizing a comprehensive design

DESIGN AREA 1: LIGHTING



ELECTRICAL LIGHTING PLAN – LEVEL ONE
SCALE: 1/8" = 1'-0"

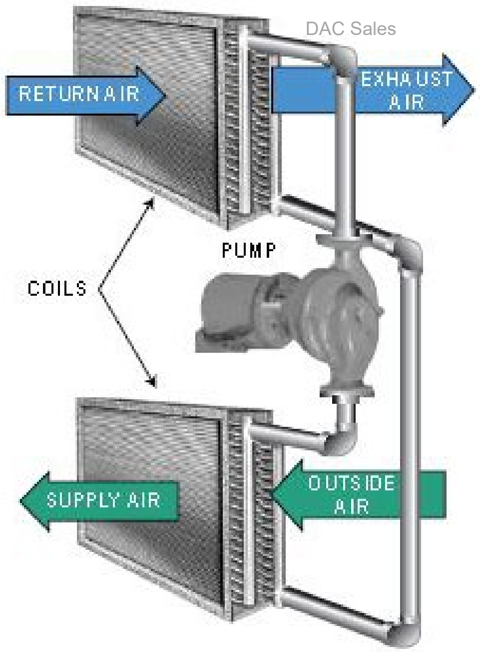
Changes Overview

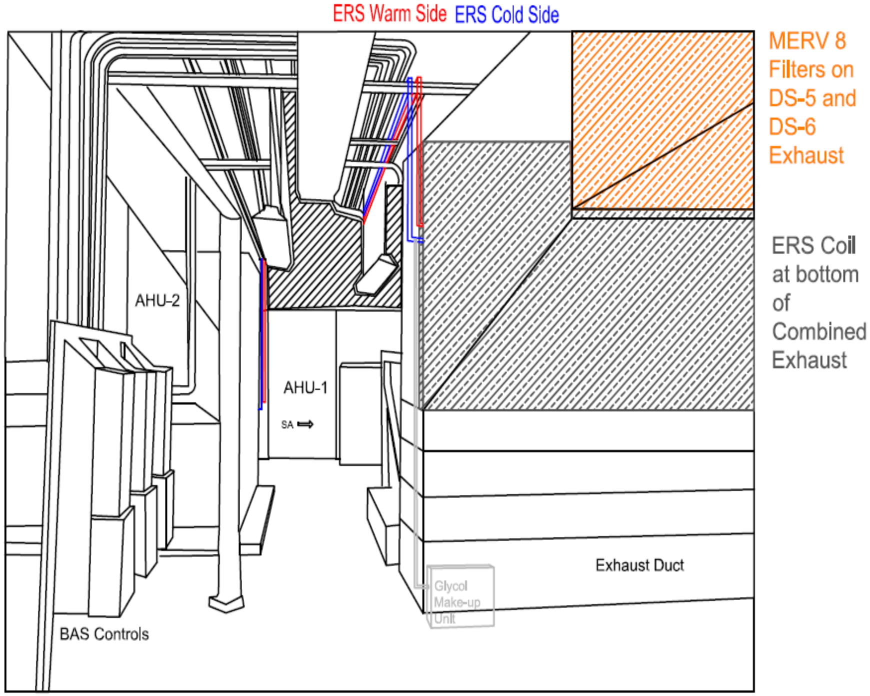
- Replace all lamps with LEDs
- Re-zoned lighting
- IR occupancy sensors (excluding labs)

The cost payback period for LEDs is approximately 3 years.

DESIGN AREA 2: HVAC

Part A: Energy Recovery System



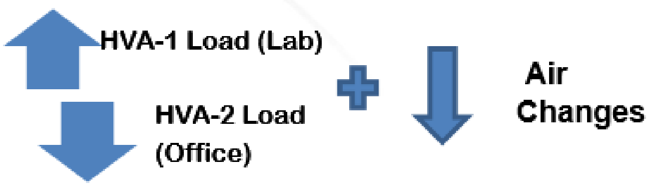


HVAC optimization is the largest source of energy savings.

DESIGN AREA 2 CONTINUED

Part B: Air Handling Adjustments

Separate Air Handling Units (AHU)



- Reduce air changes in non-biohazard or chemical hazard labs to 6 per hour
- Reduce air changes in office, corridor, and break spaces to 5 per hour
- Temperature and occupancy setbacks in offices/corridors

Standard Energy Use:

5 ACH in Offices,
10 ACH in 13 labs,
6 ACH in 4 labs

66% Savings

Maximum Energy Use:

5 ACH in Offices,
All Equipment running at max,
<10 ACH in labs.

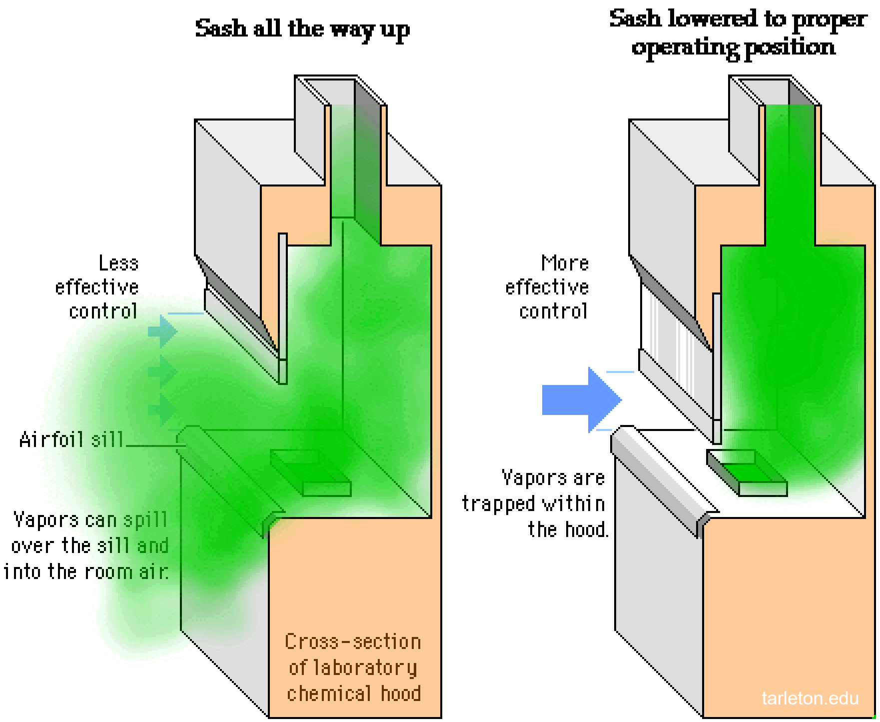
19% Savings

HVAC optimization is the largest source of energy savings.

DESIGN AREA 3: RISK BANDING & SAFETY

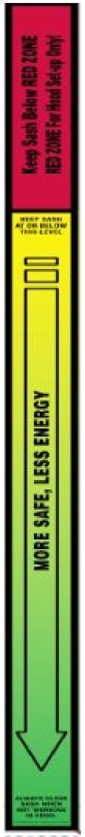
<u>Goals</u>

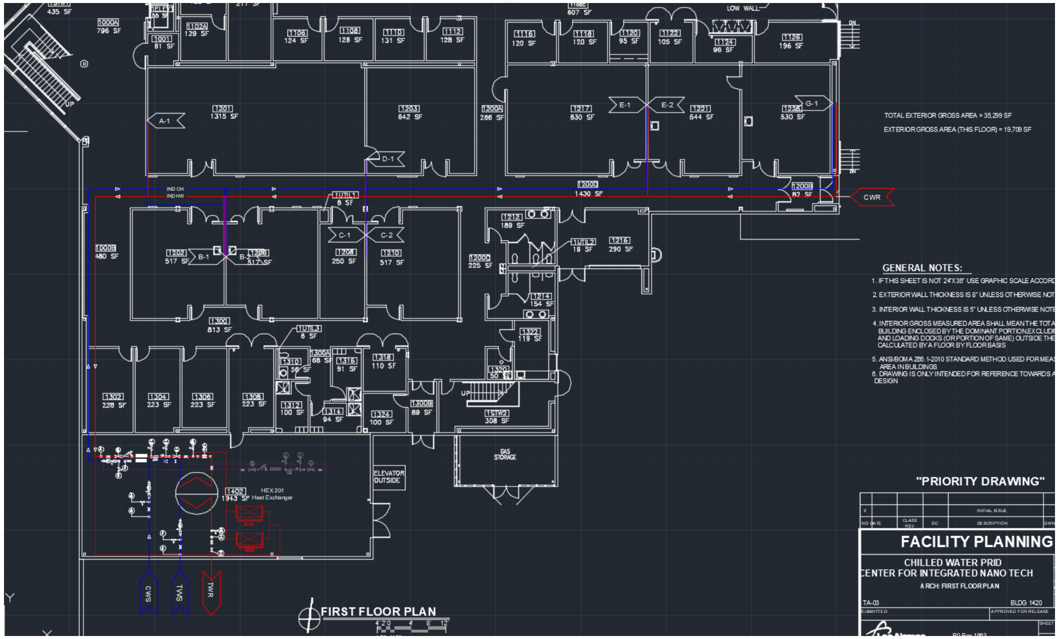
- Reduce air changes in non-biohazard or chemical hazard labs to 6 per hour
- Have ES&H retest for possible contamination hazards post-changes.



Lab culture and fume hood utilization are complimentary to our safety goals.

SMALLER DESIGN AREAS/RECOMMENDATIONS





Risk Control Band	Description
0	Negligible
1	Low
2	Moderate
3	High
4	Very High
5	Extreme

Plan of the Week (POW):

ACTION ITEMS
• Poster: finish design, print, and submit for LA-UR number
• Calculate LCCAs for each design area (separated and combined)
• Finish constructing, programming, and testing prototype
• Finish SOW, RCD, BOM, and RPA
• Prepare final group presentation (8/1/19)
• Prepare final design package (8/8/19)

INDIVIDUAL PROJECTS:

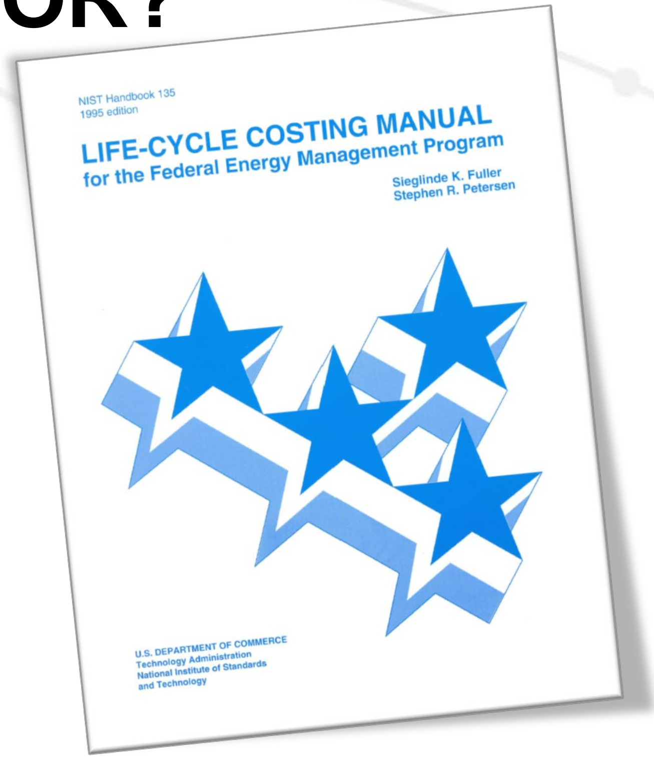
Life-Cycle Cost Analysis (LCCA) Calculator and Tests

TA-03-0223 HVAC Renovation

TA-03-0030 Renovation Feasibility Study

LCCA: WHY A CALCULATOR?

- LANL engineers struggling to commit time to thorough LCCA
- Required by Engineering Standards Manual STD-342-100
- Hand calculations are now automated and graphed, saving several hours
- Spreadsheet can be used for whole projects and components of projects



UTILITIES AND INSTITUTIONAL FACILITIES

LANL Engineers need an easier way to analyze life-cycle cost.

CALCULATOR EXAMPLE:

Cost of Gas vs. Electric LCC Analysis Calculator - See Appendix C in NIST Handbook 135 for Guidance

PROJECT IDENTIFICATION		Notes
Project Name:	Fun Project Yay	
Fiscal year:	1995	
Location:	LANL	DoE region
Base Date (BD):	5/3/2019	MM/DD/YYYY
Service Date (SD):	8/25/2022	MM/DD/YYYY
Design Feature to be Evaluated:	Energy source	
List Constraints:		Attach page if needed
Energy/Water Conservation Study? (FEMP)	Yes	(yes or no)
OMB A-94?	No	Office of Management and Budget circular?

BASE CASE AND ALTERNATIVES

Name and describe base case and alternatives to be analyzed:

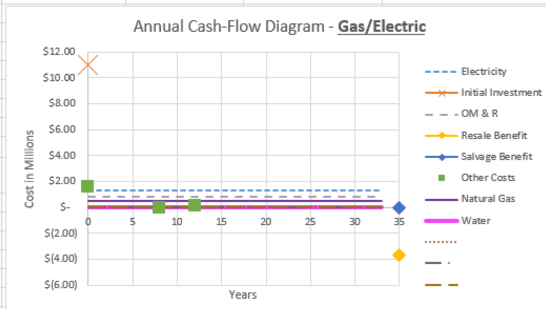
Base case is 100% electric energy, as preferred by management.

GENERAL INFORMATION:		
Name of Analyst:	Matney Juntunen	
Phone Number:	406-203-8951	
Z-Number:	341830	
Date of Study Completion:	6/12/2019	MM/DD/YYYY

KEY DATES		Notes
Years of Life:	35	Quantity (commonly 35 years)
BD:	5/3/2019	
SD:	8/25/2022	
End of Study:	6/12/2019	

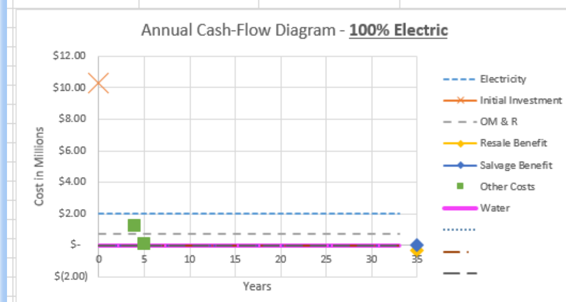
CASH FLOWS (IN MILLIONS) FOR GAS/ELECTRIC

CATEGORY	YEAR # IN LIFETIME	COST PER YEAR	Notes
Initial investment:	0	$ 11.00	
Total Electricity:	all	$ 1.30	(Usually $0.08 per kW/h)
OM & R:	all	$ 0.80	
Total Natural Gas:	all	$ 0.50	(Usually $3.5 per million Btu)
Water:	all	$ 0.00000170	
	all		
	all		
	all		
Gas Line Extension	0	$ 1.60	
Fan Replacement	12	$ 0.16	Other **One-Time** Costs
Economizer Install	8	$ 0.0125	(replacements, disposal, etc.)
Resale value:	35	$ 3.70	End of Life Expectancy
Salvage Value:	35	$ 0.03	End of Life Expectancy
Total Cost of Lifetime (Millions):		**$ 474.05**	



CASH FLOWS (IN MILLIONS) FOR 100% Electric

CATEGORY	YEAR # IN LIFETIME	COST	Notes
Initial investment:	0	$ 10.30	
Total Electricity:	all	$ 2.00	(Usually $0.08 per kW/h)
OM & R:	all	$ 0.70	
Water	all	$ 0.0000017	
	all		
	all		
	all		
Fan Replacement	12	$ 1.20	Other **One-Time** Costs
Economizer Install	4	$ 0.10	(replacements, disposal, etc.)
Resale value:	35	$ 0.35	End of Life Expectancy
Salve Value:	35	$ 0.03	End of Life Expectancy
Total Cost of Lifetime (Millions):		**$ 455.93**	



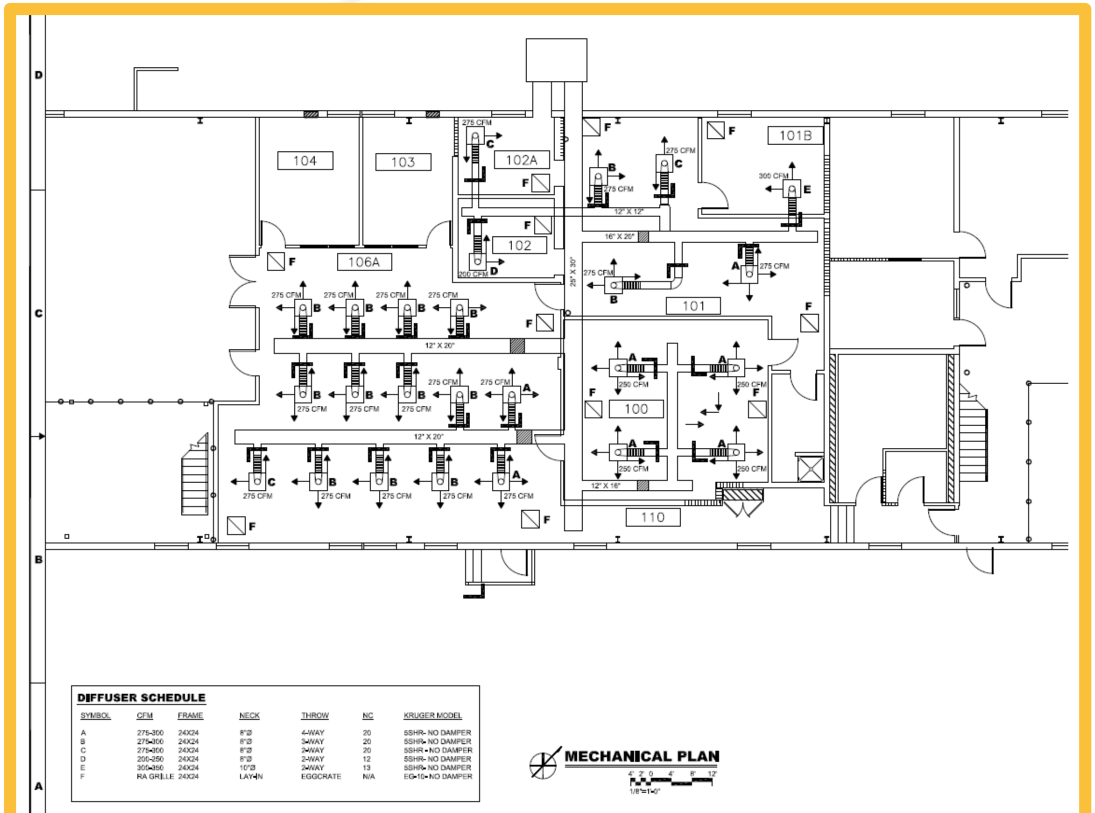
User entries are coded for processing throughout the workbook.

PILOT LCCA ANALYSES:

Past	Present	Future
• TA-15 Office Trailers • CINT Lighting (Troy)	• CINT HVAC • TA-16 Fire Station Solar Option	• CINT Smart Lab (total renovation) • SM-30 Proposal

Life-cycle cost is required at LANL to analyze federal energy requirements/standards.

OTHER HVAC PROJECTS:



TA-03-0030:

- Heat load calculations
- LCCA
- Design decisions
- Working with other intern from UI

Calculations are visible to the user, but the main objectives are clearly outlined.

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Accomplishments and Barriers:

- Completed TA-15 Office Trailer LCCA
- Estimate received for TA-16 fire station
- Continued LCCA for CINT
- Quote and heat calcs for design for TA-03-0223 HVAC

BARRIERS:

- Response time from sources regarding line-item costs

My individual compliments our Smart Lab's needs.

Plan of the Week (POW)

STEPS OF ACTION
• Run fire station LCCA
• Propose HVAC solution for TA-02-0223
• Prepare for LCCA presentation in August

I am beginning to see final results to these projects.

Questions?

UNCLASSIFIED

A.6 ENERGY CALCULATIONS AND CONCLUSIONS

Lighting

Total annual cost savings:	$ 5,260.00	
Total annual energy savings:	224.35	MMBTU
Total annual energy savings:	4%	

HVAC

ERS: (Thermal and Electric)

Total annual cost savings:	$ 3,712.67	
Total annual energy savings:	876.03	MMBTU

AHU Split/ACH: (Thermal)

Total annual cost savings:	$ 24,482.49	
Total annual energy savings:	7,310.00	MMBTU
Total annual energy savings:	50%	

Total Thermal (Natual Gas) Energy (ERS + ACH)

Total annual cost savings:	$ 26,937.79
Total annual energy savings:	55%

Electric Energy (LEDs, ERS, HVAC fans)

Total annual cost savings:	$ 9,898.72
Total annual energy savings:	8%

Total CINT Smart Lab

Current CINT Energy Cost:	$ 166,135.67	
Total annual savings:	$ 36,836.51	
New annual cost:	$ 129,299.15	
Total Cost Savings Percentage:	**22%**	
CINT Current Energy:	19,657.15	MMBTU
New CINT Energy Savings:	8,554.51	MMBTU
Total Energy Savings Percentage:	**44%**	

Current CINT Energy Calculations

	Electricity in CINT: 2017 kWH	2018 kWH
Jan	105,928	123,993
Feb	101,792	114,430
Mar	111,827	119,706
Apr	109,609	119,596
May	117,708	134,468
Jun	135,613	144,678
Jul	145,987	149,151
Aug	138,881	140,460
Sep	124,876	129,163
Oct	119,693	111,350
Nov	117,377	100,121
Dec	117,992	97,771
Totals:	1,447,283	1,484,887

	Sky Spark CINT Thermal MMBTU	Drawing Thermal CINT MMBTU	Season
Jan	~~256~~	1,929	W
Feb	~~256~~	1,929	W
Mar	~~256~~	1,929	W
Apr	~~154~~	1,157	Avg
May	~~154~~	1,157	Avg
Jun	~~51~~	385	S
Jul	~~51~~	385	S
Aug	~~51~~	385	S
Sep	~~154~~	1,157	Avg
Oct	~~154~~	1,157	Avg
Nov	~~154~~	1,157	Avg
Dec	~~256~~	1,929	W

Annual Electric Energy:	1,466,085	kWh
	5,002,487,272	BTU
	5,002.49	MMBTU
Cost per kW:	$ 0.08	
Annual Electric Cost:	**$ 117,286.80**	
*Cooling pumps are electric		

~~Sky Spark:~~		
~~Annual Total Thermal Energy:~~	~~1,946~~	~~MMBTU~~
~~Annual Cost of Steam for Heat:~~	~~$ 77,851.94~~	
~~%Steam of Total Energy~~	~~28.01%~~	
Original Drawings:		
Annual Total Thermal Energy:	14,655	MMBTU
Annual Cost of Steam for Heat:	$ 48,848.87	
%Steam of Total Energy	74.55%	

Total MMBTU Annual Energy (electric +thermal): 19,657 MMBTU
Total Annual Energy Cost (electric +thermal): $ 166,135.67
(117 Million)

Steam plant thermal efficiency: 0.75
Field loss: 0.15
Total System efficiency: 0.6
Cost of fuel per month (MMBTU): $ 2.00

BTU/Hr = CFM*4.5*deltaenthalpy
ACH = (CFM x 60)/Room Volume
Volume HVA1: ft^3 92,350.00
Volume HVA2: ft^3 161,266.20

Cooling

Summer Dry bulb (F):	89	Summer MA change in enthalpy: HVA2	
Summer Relative Humidity:	30%	Inside temp:	75
Summer design temp indoors:	75	Outside temp:	89
Summer Delta Enthalpy:	4.22	MA temp:	77.1
		Summer change in enthalpy:	1.2

Heating

Winter Dry bulb (F):	5	Winter MA change in enthalpy: HVA2	
Winter Relative Humidity:	30%	Inside temp:	72
Winter design temp indoors:	72	Outside temp:	5
Winter Delta Enthalpy:	22.52	MA temp:	61.95
		Winter change in enthalpy:	4.6

CINT Drawing BTU/Hr Calcs:			ACH:
Cooling HVA1 Req:	27,100	CFM	17.61
	514,629	BTU/Hr	
Monthly Total:	302.60	MMBTU	
Cooling HVA2 Req:	25,858	CFM	9.62
	139,633	BTU/Hr	
Monthly Total:	82.10	MMBTU	
Heating HVA1 Req:	27,100	CFM	17.61
	2,746,314	BTU/Hr	
Monthly Total:	1,614.83	MMBTU	
Heating HVA2 Req:	25,815	CFM	9.60
	534,371	BTU/Hr	
Monthly Total:	314.21	MMBTU	

HVA1: 588 hrs per month
HVA2: 588 hrs per month
Electric: 3900 hrs per year

Smart Lab Energy Calculations

Cuurent CINT lighting cost:	$	17,790.00	
LED Annual Electric Cost:	$	12,530.00	
Total annual lighting savings:	**$**	**5,260.00**	4%
		224.35	MMBTUs

ERS Summer Savings:			
Energy savings per heating degree Air change:		8,586	BTU
Number of annual heating days:		90	days above 78 deg
Air Changes Per Day: (4 hrs of cooling)		27	AC/Day
Total ERS Annual Summer Savings:		21.18	MMBTU ELECTRIC
		6,205.75	annual kWh
	$	496.46	
ERS Annual Fall/Spring Savings:			
Daily Summer Savings:	$	5.52	
		0.24	MMBTU
Daily Winter Savings:	$	14.12	
		4.24	MMBTU
Daily Fall/Spring Savings:	$	9.82	
		2.24	MMBTU
Number of Fall/Spring Days		155	days
Total Fall/Spring Savings:	$	1,521.81	
		346.53	MMBTU
ERS Winter Savings:			
Energy savings per heating degree Air change:		25,758	BTU
Number of annual heating days:		120	days below 72 deg
Air Changes Per Day: (24 hrs of heating)		164.45	AC/Day
Total ERS Annual Winter Savings:		508	MMBTU THERMAL
	$	1,694.40	
Total Annual ERS Cost Savings:	**$**	**3,712.67**	
Total Annual ERS Energy Savings:		**876.03**	MMBTU

	CINT Thermal MMBTU	Season
Jan	962	W
Feb	962	W
Mar	962	W
Apr	577	Avg
May	577	Avg
Jun	192	S
Jul	192	S
Aug	192	S
Sep	577	Avg
Oct	577	Avg
Nov	577	Avg
Dec	962	W

Annual Heating Energy Savings:	7,310	MMBTU
New Annual Cost of Steam for Heat:	**$ 24,366.38**	
%Steam of Total Energy	59.37%	

Decreased fan speed = electric savings		
ERS+LED savings in CINT:	12.467	kW (per hour)
Supply Fans 1 + 2 savings at 6.85 ACH:	4.687	kW (per hour)
Supply Fan 1 savings at 8.7 ACH:	0.138	kW (per hour)
Exhaust Fan 1 minimum savings:	0.138	kW (per hour)
Hourly fan electric savings:	4.825	kW (per hour)
Annual fan electric savings:	**42,267**	**kwh**
$	**3,381.36**	
	144.22	MMBTU

Smart Lab BTU/Hr Calcs:			ACH:	
Cooling HVA1 Req:	13,398	CFM	**10 ACH in 13 labs, 6 ACH in 4 labs, 5 ACH in non-labs (see "Statistics" tab)**	8.704493774 average ACH
	254,422	BTU/Hr		
Monthly Total:	149.60	MMBTU		
Cooling HVA2 Req:	13,439	CFM		5
	72,570	BTU/Hr		
Monthly Total:	42.67	MMBTU		
Heating HVA1 Req:	13,398	CFM		8.704493774 average ACH
	1,357,720	BTU/Hr		
Monthly Total:	798.34	MMBTU		
Heating HVA2 Req:	13,439	CFM		5
	278,184	BTU/Hr		
Monthly Total:	163.57	MMBTU		
			Building avg ACH:	6.8522469

ACH Savings:		
Current thermal cost:	$	48,848.87
New thermal cost:	$	24,366.38
Annual thermal savings:	**$**	**24,482.49**
		50%

TOTAL COMPLETE SMART LAB SAVINGS:					
Current CINT Energy Cost:	$	166,135.67	CINT Current Energy	19,657	MMBTUs
Total annual savings:	$	36,836.51	New CINT Energy Savings	8,554.51	MMBTUs
New annual cost:	$	129,299.15	**Total Energy Savings Percentage:**	**44%**	
Total Cost Savings Percentage:		**22%** OVERALL			

Total Thermal Savings:	$	26,937.79	
New Thermal Cost:	$	21,911.08	
Percent thermal total savings:		**55%**	ERS+AHU
Total Electric Savings:	$	9,898.72	
New Electric Cost:	$	107,388.08	
Percent Electric total savings:		**8%**	Lighting + ERS

Current Thermal in CINT HVA-2:

Category	Amount	Units
Min (Efficient) Air Flow:	12,300.00	CFM
Current Min Air Changes:	4.58	ACH
Current Operating ACH:	9.61	ACH
Current Operating Flow:	25,825.00	CFM
Current BTU/Hr HVA2 (9.6 ACH):	**490,416.75**	**BTU/Hr**
Min BTU/Hr HVA2 (4.58 ACH):	233,577.00	BTU/Hr

Changes Thermal in CINT HVA-2:

Category	Amount	Units
Calculated Flow:	13,154.57	CFM
Calculated ACH:	#REF!	ACH
New Operating ACH:	5.00	ACH
New Operating Flow (5 ACH):	**13,438.85**	**CFM**
Calculated BTU/Hr:	249,805.33	BTU/Hr
New HVA2 Operating BTU/Hr (5 ACH):	**255,203.76**	**BTU/Hr**

Calculations for Full Capacity HVA2:

Total HVA-2 Cool Demand:	249,805.33	BTU/Hr
	13,154.57	CFM
Sum of HVA-2 Room Volumes:	161,266.20	ft^3
Max HVA-2 Ability:	29,690.00	CFM

Calculations for Full Capacity HVA1:

Total HVA-1 Cool Demand:	555,789.86	BTU/Hr
	29,267.50	CFM
Sum of HVA-1 Room Volumes:	92,350.00	ft^3
Max HVA-1 Ability:	31,200.00	CFM

Enthalpy Assumptions for CINT:

Summer Dry bulb (F):	89	F
Summer Relative Humidity:	0.3	
Summer Design Temp Indoors:	75	F
Summer Delta Enthalpy:	4.22	BTU/lb dry air
Winter Dry bulb (F):	5	F
Winter Relative Humidity:	30%	
Winter Design Temp Indoors:	72	F
Winter Delta Enthalpy:	22.52	BTU/lb dry air

CINT Thermal HVA-1 Calculations:

Category	Amount	Units
Min (Efficient) Air Flow:	21,600.00	CFM
Current Min Air Changes:	14.03	ACH
Min HVA1 BTU/Hr (7.99 ACH):	410,184.00	BTU/Hr
Current HVA1 BTU/Hr (17.6 ACH):	**514,629.00**	**BTU/Hr**
Current Operating Flow:	27,100.00	CFM
Current Operating ACH:	17.61	ACH
Flow at 10 ACH:	15,391.67	CFM
BTU/Hr for 10 ACH:	292,287.75	BTU/Hr
With all Lab doors sealed and LED Lights:		
New (Max) Operating BTU/Hr: 19 ACH	555,789.86	BTU/Hr
New (Max) Operating Flow:	29,267.50	CFM
Calculated (Max) ACH:	19.02	ACH
With 4 labs at 6 ACH:		
Total Labs SF:	9235	sf
Four labs chosen to be 6 ACH:	2991	sf
Four labs volume:	29910	ft^3
New sf at 10 ACH:	6244	sf
Other labs volume:	62440	ft^3
New total operating CFM:	13,397.67	CFM
New total operating HVA1:	**254,421.69**	**BTU/Hr**
Percent HVA1 Energy Savings from ACH:	**49%**	

Thermal Energy Savings for Air Changes Only:

Enery savings for all equipment running,	19%
Energy savings on average day with 5 ACH in offices, 6 in four labs, and 10 in rest of labs:	66%

Assumptions for "Setback" :

Room Unoccupied
All Lights Off
Temperature setpoints @ 55 and 78 F

Conversions:

BTU/Hr = CFM*4.5*deltaenthalpy
CFM = (BTU/Hr)/(4.5*deltaenthalpy)
BTU/Hr = 0.00029307107 kW
ACH = (CFM x 60)/Room Volume
X kWh = (BTU/Hr)/3412.14

Electric Rate @ LANL:	$	0.08	Per kWh

A.7 TOTAL CINT SMART LAB LCCA

TOTAL CINT SMART LAB LCCA

Instructions:

This worksheet provides the LCCA comparison between two cases: Case A and Case B. The lifetime evalued is set at a maximum of 35 years. This worksheet is formatted to be printer-friendly, do not change this format. Only DOE projects may use this calculator (no OMB). The discount factors included for payback calcultions must be updated annually with the Annual Supplement to Handbook 135.

User must fill in each applicable yellow field input area. Notes are provided for clarity when inputting values. White areas are coded to provide Life-Cycle Cost Analysis (LCCA), do not interfere with these calculations.

The following result can be concluded from this worksheet: General project identificaiton information, cash flow comparisons (visual and numerical), savings-to-investment ratio, and discount payback period.

Terminology Clarifications:

"Year in lifetime" refers to the year at which the cost takes place.

For costs not listed that occur annually, add to highlighted space in "General & Cash Flow" tab where "all" is listed. For costs not listed that occur once, add to highlighted space in "General & Cash Flow" tab where the year must be specified. Specify the year at which the cost takes place in the provided space.

"One-Time Other Costs" refers to investment and operational costs that do not occur annually. For these values, the user will also list the "year in lifetime" in the corresponding input cell. Examples of these costs include replacements such as roofing, mechanical equiptment, etc.

"Lower-First-Cost Option" refers to the cost in a category belonging to the option with the lowest initial investment. *"Higher-First-Cost Option"* refers to the cost in a category belonging to the option with the highest initial investment.

Citations:

Life-Cycle Costing Manual for the Federal Energy Management Program, NIST Handbook 135, 1995 Edition:

https://www.nist.gov/publications/life-cycle-costing-manual-federal-energy-management-program-nist-handbook-135-1995

Energy Price Indices and Discount Factors LCCA 2019, Annual Supplement to Handbook 135 :

https://www.nist.gov/publications/energy-price-indices-and-discount-factors-life-cycle-cost-analysis-150-2019-annual

Utilities & Infrastructure Facility Operations, Los Alamos National Laboratory.
Author: Matney Juntunen

Initial Investment Calculator:

Instructions:	Fill in the following values if applicable to the project. The initial investment should include all costs which allow the project to begin its lifetime. **Note: Costs are in Thousands.**

Current State INITIAL INVESTMENT:

TOPIC	**COST**
All Materials:	
All labor:	
TAB:	
BAS Controls:	
Safety:	
Inspections:	
Building Outage:	
Parking Lot:	
Water Drainage:	
Other Contruction Costs:	
Gas Extension Calulations:	
Case A Initial Investment:	**$ -**

Smart Lab INITIAL INVESTMENT:

TOPIC	**COST**
ERS Materials/Labor:	$ 276.19
AHUs Materials/Labor:	$ 6.86
TAB:	$ 15.00
BAS Controls:	$ 15.00
Safety:	
Inspections:	
Building Outage:	
Parking Lot:	
Water Drainage:	
Other Contruction Costs:	
Gas Extension Calulations:	
LED Lighting:	$ 144.93
Lab ACH TAB and BAS:	$ 12.00
Case A Initial Investment:	**$ 469.98**

Note: Gasket = $13.72 per LF

Gasline and Water Calculations:

Gas Line Extension Calculations:		Notes:
Linear measurement of extension (in feet):		For lines up to 10 inch diameter
Cost of line per linear foot:	$ 0.40	Includes cost of construction, quoted 5/28/19
Cost per tie-in:	$ 5.00	
Cost per reg station:	$ 5.00	
Number of tie-ins:		
Number of reg stations:		
Total Cost of Line Extension/Tie-Ins:	$ -	7/22/19

Annual Water Cost Calculations:		Notes:
Number of Office Workers:		
(in kilo-gallons):	0.025	Quoted 5/28/19
Needed (in kilo-gallons):		
Cost of Water (per kgal)	$ 0.00340000	Cost in thousands, quoted 5/28/19 at $3.40 per kgal
Total Annual Cost of Water:	$ -	

Information Needed to Complete this Workbook:

Current Cost: (in Thousands)

CATEGORY	YEAR # IN LIFETIME	COST PER YEAR	Notes
Initial investment:	1	$ -	
Total Electricity:	Annual	$ 117.29	(Usually $0.08 per kW/h)
OM & R:	Annual		Lifetime of 6 years = zero OM&R
Total Natural Gas:	Annual	$ 48.85	(Usually $3.5 per million Btu)
Water:	Annual	$ -	
Resale value:			End of Life Expectancy
Salvage Value:			End of Life Expectancy

Smart Lab Cost: (in Thousands)

CATEGORY	YEAR # IN LIFETIME	COST PER YEAR	Notes
Initial investment:	1	$ 469.98	
Total Electricity:	Annual	$ 107.91	(Usually $0.08 per kW/h)
OM & R:	Annual		Lifetime of 6 years = zero OM&R
Total Natural Gas:	Annual	$ 21.98	(Usually $3.5 per million Btu)
Water:	Annual	$ -	
Resale value:			End of Life Expectancy
Salvage Value:			End of Life Expectancy

Cost of Gas vs. Electric LCC Analysis Calculator - See Appendix C in NIST Handbook 135 for Guidance

PROJECT IDENTIFICATION		Notes
Project ID No:	103849	
Fiscal year:	2019	
Location:	TA-03-1420	DoE Region, LANL Building
Base Date (BD):	7/24/2019	MM/DD/YYYY (Start of study)
Service Date (SD):	12/17/2019	MM/DD/YYYY (Occupancy)
Design Feature to be Evaluated:	HVAC and lighting renovation	
List Constraints:		Attach page if needed
Energy/Water Conservation Study? (FEMP)	No	
OMB A-94?	No	Office of Management and Budget circular not at LANL

BASE CASE AND ALTERNATIVES

Name and describe base case (lower initial investment) and alternatives to be analyzed. Include any relevent assumptions:

Comparing if the Smart Lab renovaiton should be implemented at CINT.

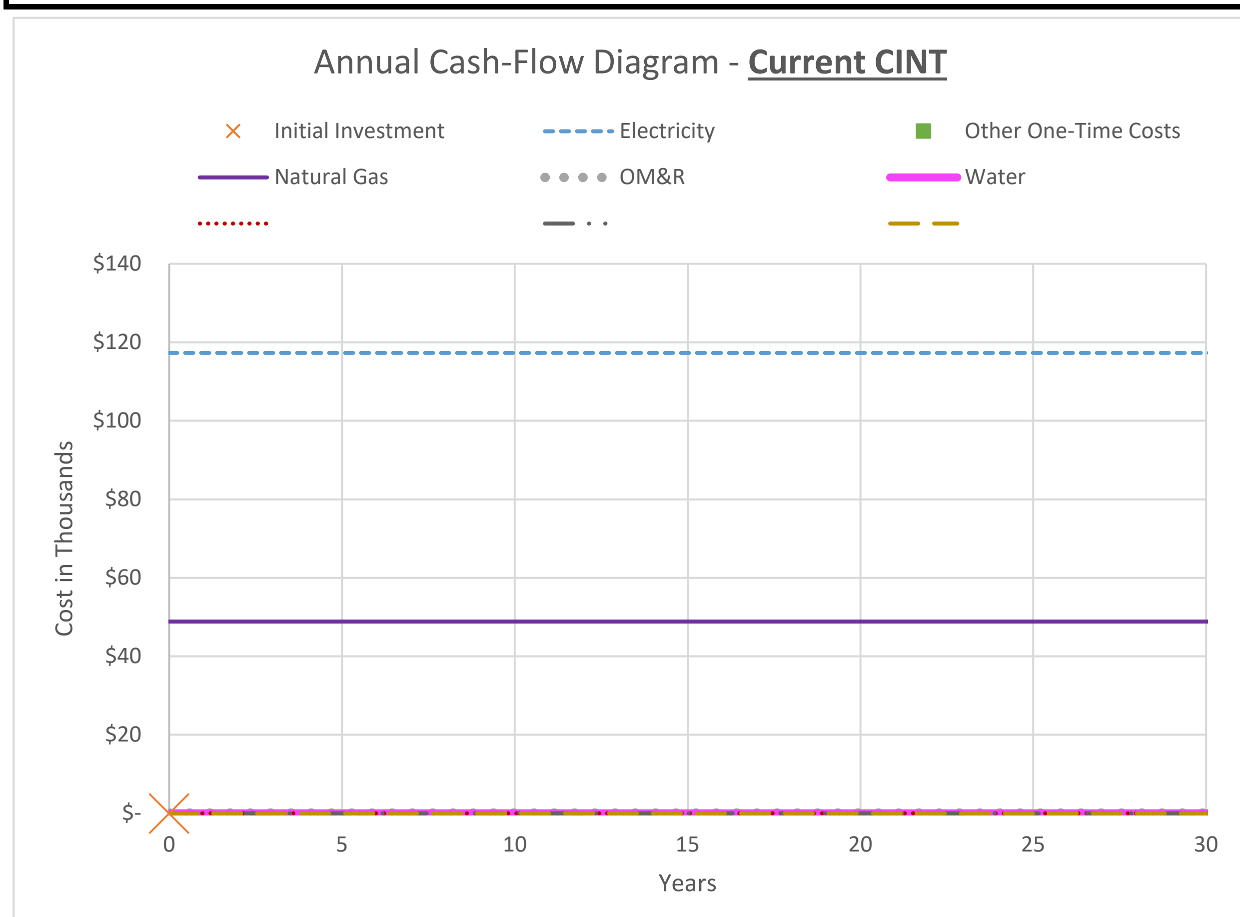
GENERAL INFORMATION:		
Name of Analyst:	Matney Juntunen	
Phone Number:	55-667-1975	
Z-Number:	341830	
Date of Study Completion:	8/2/2019	MM/DD/YYYY

KEY DATES		Notes
Years of Life:	25	Quantity (commonly 25-30 years)
BD:	7/24/2019	
SD:	12/17/2019	
End of Study:	8/2/2019	

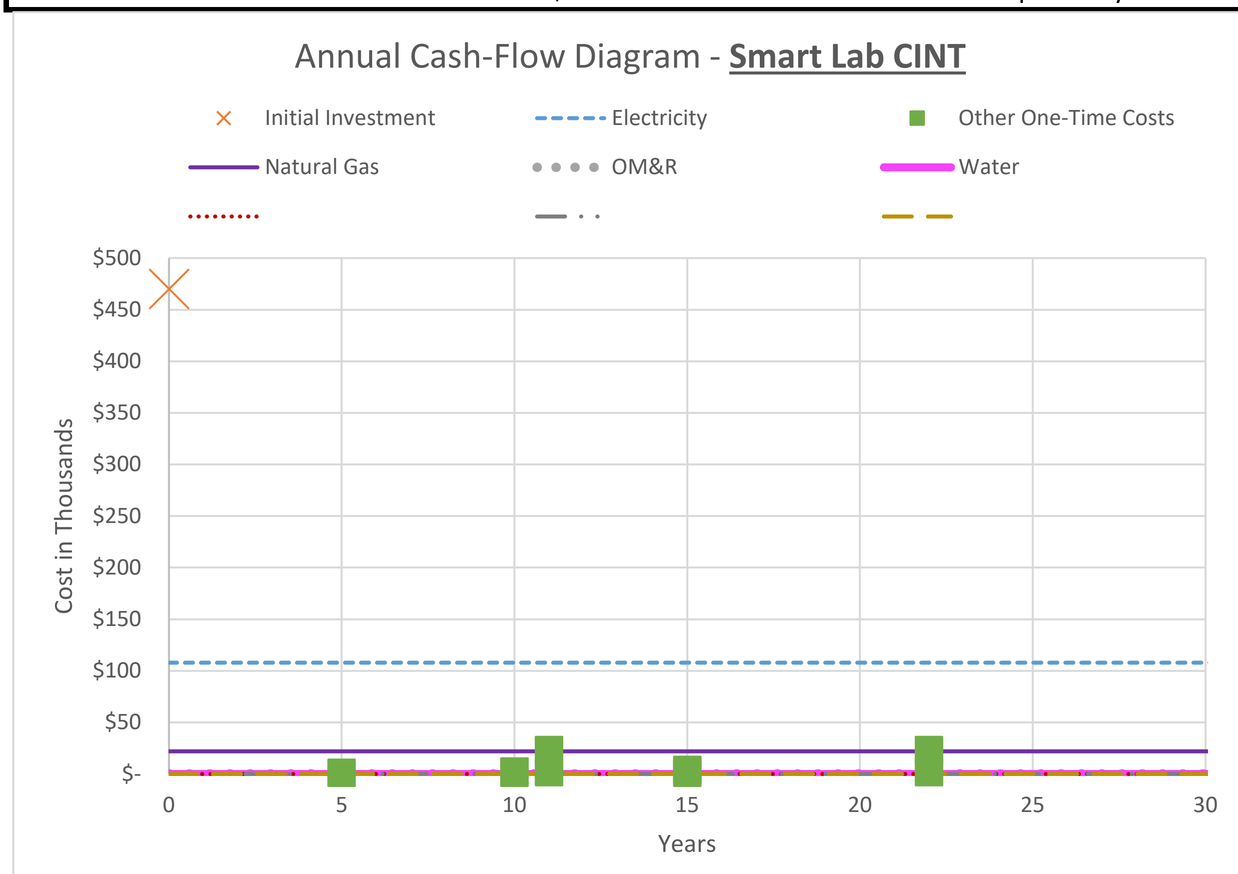
Cash Flows Last Updated 7/23/2019

CASH FLOWS (IN THOUSANDS) FOR CASE A - Do Nothing

CATEGORY	YEAR # IN LIFETIME	COST PER YEAR	Notes
Initial investment:	1	$ -	
Total Electricity:	Annual	$ 117.29	(Usually $0.08 per kW/h)
OM & R:	Annual	$ -	
Total Natural Gas:	Annual	$ 48.85	(Usually $3.5 per million Btu)
Water:	Annual	$ -	
	Annual		
	Annual		
	Annual		
			Other **One-Time** Costs
Resale value:	0	$ -	End of Life Expectancy
Salvage Value:	0	$ -	End of Life Expectancy



CASH FLOWS (IN THOUSANDS) FOR CASE B - Smart Lab Changes				
CATEGORY	YEAR # IN LIFETIME	COST		Notes
Initial investment:	1	$	469.98	
Total Electricity:	Annual	$	107.91	(Usually $0.08 per kW/h)
OM & R:	Annual	$	-	
Total Natural Gas:	Annual	$	21.98	(Usually $3.5 per million Btu)
Water	Annual	$	-	
	Annual			
	Annual			
	Annual			
MERV 8 Filters	5	$	0.9280	Other **One-Time** Costs (replacements, disposal, etc.)
MERV 8 Filters	10	$	0.9280	
MERV 8 Filters	15	$	0.9280	
Temp/Press Sensors	10	$	2.30	
Pump Replacement	15	$	3.95	
Bulb Recycle	11	$	1.67	
Bulb Recycle	22	$	1.67	
Bulb Replace	11	$	23.00	
Bulb Replace	22	$	23.00	
Resale value:	0	$	-	End of Life Expectancy
Salve Value:	0	$	-	End of Life Expectancy



Colum	Column2	Column3	Column4	Column5	Column6	Column63	Column62	Column7	Column16	Column17
Data for Graphs - Case B										
Year	Init. Inv.	Electricity	OMR	Gas	Water	Other1	Other2	Other3	Resale	Salvage
0	$ -	$ 117.29	$ -	$ 48.85	$ -	$ -	$ -	$ -		
3		$ 117.29	$ -	$ 48.85	$ -	$ -	$ -	$ -		
5		$ 117.29	$ -	$ 48.85	$ -	$ -	$ -	$ -		
7		$ 117.29	$ -	$ 48.85	$ -	$ -	$ -	$ -		
9		$ 117.29	$ -	$ 48.85	$ -	$ -	$ -	$ -		
11		$ 117.29	$ -	$ 48.85	$ -	$ -	$ -	$ -		
13		$ 117.29	$ -	$ 48.85	$ -	$ -	$ -	$ -		
15		$ 117.29	$ -	$ 48.85	$ -	$ -	$ -	$ -		
17		$ 117.29	$ -	$ 48.85	$ -	$ -	$ -	$ -		
19		$ 117.29	$ -	$ 48.85	$ -	$ -	$ -	$ -		
21		$ 117.29	$ -	$ 48.85	$ -	$ -	$ -	$ -		
23		$ 117.29	$ -	$ 48.85	$ -	$ -	$ -	$ -		
25		$ 117.29	$ -	$ 48.85	$ -	$ -	$ -	$ -		
27		$ 117.29	$ -	$ 48.85	$ -	$ -	$ -	$ -		
29		$ 117.29	$ -	$ 48.85	$ -	$ -	$ -	$ -		
31		$ 117.29	$ -	$ 48.85	$ -	$ -	$ -	$ -		
33		$ 117.29	$ -	$ 48.85	$ -	$ -	$ -	$ -		
35									$ -	$ -

Colur	Column2	Column3	Column4	Column5	Column6	Column7	Column8	Column9	Column10	Column11
Data for Graphs - Case B										
Year	Init. Inv.	Electricity	OMR	Water	Other1	Other2	Other3	Resale	Salvage	Nat Gas
0	$ 469.98	$ 107.91	$ -	$ -	$ -	$ -	$ -			$ 21.98
3		$ 107.91	$ -	$ -	$ -	$ -	$ -			$ 21.98
5		$ 107.91	$ -	$ -	$ -	$ -	$ -			$ 21.98
7		$ 107.91	$ -	$ -	$ -	$ -	$ -			$ 21.98
9		$ 107.91	$ -	$ -	$ -	$ -	$ -			$ 21.98
11		$ 107.91	$ -	$ -	$ -	$ -	$ -			$ 21.98
13		$ 107.91	$ -	$ -	$ -	$ -	$ -			$ 21.98
15		$ 107.91	$ -	$ -	$ -	$ -	$ -			$ 21.98
17		$ 107.91	$ -	$ -	$ -	$ -	$ -			$ 21.98
19		$ 107.91	$ -	$ -	$ -	$ -	$ -			$ 21.98
21		$ 107.91	$ -	$ -	$ -	$ -	$ -			$ 21.98
23		$ 107.91	$ -	$ -	$ -	$ -	$ -			$ 21.98
25		$ 107.91	$ -	$ -	$ -	$ -	$ -			$ 21.98
27		$ 107.91	$ -	$ -	$ -	$ -	$ -			$ 21.98
29		$ 107.91	$ -	$ -	$ -	$ -	$ -			$ 21.98
31		$ 107.91	$ -	$ -	$ -	$ -	$ -			$ 21.98
33		$ 107.91	$ -	$ -	$ -	$ -	$ -			$ 21.98
35								$ -	$ -	

Case A Investment-Costs: (in Thousands)

CATEGORY	AMOUNT	Notes	Year in Lifetime	DISCOUNT FACTOR (**SPV**)	Notes	PRESENT VALUE
Initial Investment:	$ -		1		(Rates included in NIST Handbook 135 Annual Suppliment discount factors. **Must discount to ending year of**	$ -
Resale:	$ -		25			$ -
Salvage:	$ -		25			$ -
		See previous sheet values and parts				$ -
						$ -
						$ -
						$ -
						$ -
						$ -
					Total Investment-Related Costs:	$ -

Case A Operation-Related Costs: (in Thousands)

CATEGORY	AMOUNT	Notes	Year in lifetime/end year of occurances	FACTOR (**UPV or SPV**)	Notes	PRESENT VALUE
Total Electricity:	$ 117.29		25	1.02	(Rates included in NIST Handbook 135 Annual Suppliment discount factors. **Must discount to ending year of**	$ 119.63
OM & R:	$ -		25			$ -
Total Natural Gas:	$ 48.85		25	1.36		$ 66.43
Water:	$ -		25			$ -
		See previous sheet values and parts				$ -
						$ -
						$ -
						$ -
						$ -
					Total Operation-Related Costs:	$ 186.07

Total Case A Present Value Life Cycle Costs: $ 186.07

Note: See Tables from the *Energy Price Indices and Discount Factors LCCA 2019, Annual Supplement to Handbook 135* to find discount factors.

UPV is for uniform/annual costs, while SPV is for single expense/one-time costs.

Case B Investment-Related Costs: (in Thousands)

CATEGORY	AMOUNT	Notes	Year in Lifetime	DISCOUNT FACTOR (**SPV**)	FACTOR TABLE NO.	PRESENT VALUE
Initial Investment:	$ 469.98		1	0.971	(Rates included in NIST Handbook 135 Annual Suppliment discount factors. **Must discount to ending year of occurance**).	$ 456.35
Resale:	$ -		25			$ -
Salvage:	$ -		25			$ -
Bulb Replace	$ 23.00	See previous sheet values and parts	11	0.722		$ 16.61
Bulb Replace	$ 23.00		22	0.522		$ 12.01
						$ -
						$ -
						$ -
						$ -
						$ -
						$ -
						$ -
						$ -
Total Investment-Related Costs:						$ 484.96

Case B Opoeration-Related Costs: (in Thousands)

CATEGORY	AMOUNT	Notes	Year in lifetime/end year of occurances	DISCOUNT FACTOR (**SPV or UPV**)	FACTOR TABLE NO.	PRESENT VALUE
Total Electricity:	$ 107.91		25	1.02	(Rates included in NIST Handbook 135 Annual Suppliment discount factors. **Must discount to ending year of occurance**).	$ 110.06
OM & R:	$ -		25			$ -
Natural Gas:	$ 21.98		20	1.36		$ 29.90
Water	$ -		25			$ -
MERV 8 Filters	$ 0.93	See previous sheet values and parts	5	0.863		$ 0.80
MERV 8 Filters	$ 0.93		10	0.744		$ 0.69
MERV 8 Filters	$ 0.93		15	0.642		$ 0.60
Temp/Press Sensors	$ 2.30		10	0.744		$ 1.71
Pump Replacement	$ 3.95		15	0.642		$ 2.54
Bulb Recycle	$ 1.67		11	0.722		$ 1.20
Bulb Recycle	$ 1.67		22	0.522		$ 0.87
						$ -
						$ -
Total Operation-Related Costs:						$ 148.37

Total Case B Present Value Life Cycle Costs:	$	633.33

Note: See Tables from the *Energy Price Indices and Discount Factors LCCA 2019, Annual Supplement to Handbook 135* to find discount factors.

UPV is for uniform/annual costs, while SPV is for single expense/one-time costs.

Calculate Savings-to-Investment Ratio:

Operational-Related Costs:	Lower-First-Cost Option		Higher-First-Cost Option		Savings
Total Energy:	$	186.07	$	139.96	$ 46.10
OM & R:	$	-	$	-	$ -
Water:	$	-	$	-	$ -
Sum of Other Costs:	$	-	$	8.41	$ (8.41)
				Total Op. Savings (in Thousands):	**$ 37.69**

Investment-Related Costs:	Higher-First-Cost Option		Lower-First-Cost Option		Savings
Initial Investment:	$	456.35	$	-	$ 456.35
Resale+Salvage:	$	-	$	-	$ -
Sum of Other Costs:	$	28.61	$	-	$ 28.61
				Total Additional Investment (in Thousands):	**$ 484.96**

Savings-to-Investments Ratio (SIR): 0.0777

SIR is often preffered to be greater than 1. This measure is relative to the base case.

Discount Payback Period Calculation:

Table DPP1: CALCULATION OF DIFFERENTIAL AMOUNTS (IN THOUSANDS)				
Category:	Lower-First-Cost Option	Higher-First-Cost Option	Differential Amount	Notes
Initial Investment:	$ -	$ 469.98	$ (469.98)	In dollars at time of Base Date (BD).
Total Energy:	$ 166.13	$ 129.89	$ 36.24	
OM & R:	$ -	$ -	$ -	
Water:	$ -	$ -	$ -	
Sum of Other Annual Costs:	$ -	$ -	$ -	Gas/Elec Cost includes natural gas.
Merv 8 Filters	$ -	$ 0.93	$ (0.93)	User fills in **one-time cost** of same type. Place name in category column, and cost in appropriate column.
Merv 8 Filters	$ -	$ 0.93	$ (0.93)	
Merv 8 Filters	$ -	$ 0.93	$ (0.93)	
Temp/Press Sensors	$ -	$ 2.30	$ (2.30)	
Pump Replacement	$ -	$ 3.95	$ (3.95)	
Bulb Recycle	$ -	$ 1.67	$ (1.67)	
Bulb Recycle	$ -	$ 1.67	$ (1.67)	
Bulb Replacement	$ -	$ 23.00	$ (23.00)	
Bulb Replacement	$ -	$ 23.00	$ (23.00)	
Resale/Salvage	$ -	$ -	$ -	
Note: The differential amounts above will be used in **Table DPP3** below				

Table DPP2: DOE CALCULATIONS (IN THOUSANDS)

Columr	Column2	Column3	Column4	Column5	Column6	Column7	Column8
Service Year	Annual Energy Savings	Change in OM&R, Water, and Other	Change in Capital Replacements	Present Value (PV) Savings DOE	Cumulative PV Savings	Change in PV Initial Investment	PV net savings
2019	$ 36.245	$ -	$ -	$ 36.245	$ 36.245	$ (456.352)	$ (420.107)
2020	$ 35.701	$ -	$ -	$ 35.701	$ 71.946	$ (456.352)	$ (384.406)
2021	$ 35.339	$ -	$ -	$ 35.339	$ 107.284	$ (443.192)	$ (335.908)
2022	$ 35.701	$ -	$ -	$ 35.701	$ 142.985	$ (430.033)	$ (287.047)
2023	$ 36.245	$ -	$ (0.83)	$ 35.419	$ 178.404	$ (417.343)	$ (238.939)
2024	$ 36.607	$ -	$ -	$ 36.607	$ 215.011	$ (405.594)	$ (190.582)
2025	$ 37.513	$ -	$ -	$ 37.513	$ 252.525	$ (393.374)	$ (140.849)
2026	$ 38.057	$ -	$ -	$ 38.057	$ 290.582	$ (382.095)	$ (91.513)
2027	$ 38.238	$ -	$ -	$ 38.238	$ 328.820	$ (370.815)	$ (41.995)
2028	$ 38.419	$ -	$ (2.47)	$ 35.945	$ 364.765	$ (360.005)	$ 4.759
2029	$ 40.413	$ -	$ (18.35)	$ 22.058	$ 386.823	$ (349.666)	$ 37.157
2030	$ 41.319	$ -	$ -	$ 41.319	$ 428.142	$ (339.326)	$ 88.816
2031	$ 41.863	$ -	$ -	$ 41.863	$ 470.005	$ (329.457)	$ 140.548
2032	$ 42.044	$ -	$ -	$ 42.044	$ 512.049	$ (320.057)	$ 191.992
2033	$ 42.406	$ -	$ (3.23)	$ 39.181	$ 551.229	$ (310.657)	$ 240.572
2034	$ 42.406	$ -	$ -	$ 42.406	$ 593.636	$ (301.728)	$ 291.908
2035	$ 42.588	$ -	$ -	$ 42.588	$ 636.223	$ (292.798)	$ 343.425
2036	$ 42.950	$ -	$ -	$ 42.950	$ 679.173	$ (284.339)	$ 394.835
2037	$ 42.950	$ -	$ -	$ 42.950	$ 722.123	$ (275.879)	$ 446.244
2038	$ 43.131	$ -	$ -	$ 43.131	$ 765.254	$ (267.889)	$ 497.365
2039	$ 42.950	$ -	$ -	$ 42.950	$ 808.204	$ (260.369)	$ 547.835
2040	$ 43.131	$ -	$ (13.27)	$ 29.859	$ 838.063	$ (252.850)	$ 585.213
2041	$ 43.131	$ -	$ -	$ 43.131	$ 881.194	$ (245.330)	$ 635.864
2042	$ 43.131	$ -	$ -	$ 43.131	$ 924.325	$ (238.280)	$ 686.045
2043	$ 43.312	$ -	$ -	$ 43.312	$ 967.638	$ (231.231)	$ 736.407
2044	$ 43.312	$ -	$ -	$ 43.312	$ 1,010.950	$ (224.651)	$ 786.299
2045	$ 43.494	$ -	$ -	$ 43.494	$ 1,054.444	$ (218.071)	$ 836.373
2046	$ 43.675	$ -	$ -	$ 43.675	$ 1,098.119	$ (211.491)	$ 886.627
2047	$ 43.856	$ -	$ -	$ 43.856	$ 1,141.975	$ (205.382)	$ 936.593
2048	$ 44.037	$ -	$ -	$ 44.037	$ 1,186.012	$ (199.272)	$ 986.740
2049	$ 44.219	$ -	$ -	$ 44.219	$ 1,230.231	$ (193.632)	$ 1,036.598
End of Lifetime							

Notes: Use tables **Ca-4** through **Ca-5** of the *Energy Price Indices and Discount Factors LCCA 2019, Annual Supplement to Handbook 135* (page 39) to calculate annual energy savings.
https://www.nist.gov/publications/energy-price-indices-and-discount-factors-life-cycle-cost-analysis-

Table DPP3: CALCULATE COMPONENTS OF DPP CALCULATION TABLE ABOVE

Year	Energy Savings	Fuel Index - Commercial Electricity (2019)	Fuel Index - Commercial Natural Gas (2019)	Other One-Time Cost Differentials	<-- Notes	SPV Factor Index **DOE** Discount Rate (2019)	UPV Factor Index **DOE** Discount Rate (2019)
2019	$ 36.24	1.00	1.00		User enters differential amount (Table DPP1, Column E) into correct year.	0.971	0.971
2020	$ 36.24	0.96	1.01			0.971	0.971
2021	$ 36.24	0.93	1.02			0.943	1.913
2022	$ 36.24	0.94	1.03			0.915	2.829
2023	$ 36.24	0.95	1.05	$ (0.93)		0.888	3.717
2024	$ 36.24	0.96	1.06			0.863	4.580
2025	$ 36.24	0.98	1.09			0.837	5.417
2026	$ 36.24	1.00	1.10		A negative value is shown inside parentheses, and must be entered as negative in the input section.	0.813	6.230
2027	$ 36.24	1.00	1.11			0.789	1.020
2028	$ 36.24	1.00	1.12	$ (3.23)		0.766	7.786
2029	$ 36.24	1.00	1.23	$ (24.67)		0.744	8.530
2030	$ 36.24	1.01	1.27			0.722	9.253
2031	$ 36.24	1.02	1.29			0.701	9.954
2032	$ 36.24	1.02	1.30			0.681	10.635
2033	$ 36.24	1.03	1.31	$ (4.88)		0.661	11.296
2034	$ 36.24	1.02	1.32			0.642	11.938
2035	$ 36.24	1.02	1.33			0.623	12.561
2036	$ 36.24	1.03	1.34			0.605	13.166
2037	$ 36.24	1.03	1.34			0.587	13.754
2038	$ 36.24	1.03	1.35			0.570	14.324
2039	$ 36.24	1.02	1.35			0.554	14.877
2040	$ 36.24	1.02	1.36	$ (24.67)		0.538	15.415
2041	$ 36.24	1.02	1.36			0.522	15.937
2042	$ 36.24	1.01	1.37			0.507	16.444
2043	$ 36.24	1.01	1.38			0.492	16.936
2044	$ 36.24	1.00	1.39			0.478	17.413
2045	$ 36.24	1.00	1.40			0.464	17.877
2046	$ 36.24	1.00	1.41			0.450	18.327
2047	$ 36.24	1.00	1.42			0.437	18.764
2048	$ 36.24	1.00	1.43			0.424	19.188
2049	$ 36.24	0.99	1.45			0.412	19.600

Use **Tables od Section A** of the *Energy Price Indices and Discount Factors LCCA 2019, Annual Supplement to Handbook 135* (page 8) to find SPV and UPV factors.

Discount Payback Period Result: FEMP Project

First Positive Savings:	$ 4.759
PAYBACK PERIOD:	10
FISCAL YEAR OF DISCOUNT PAYBACK:	2029

Note: Discount payback period measures the time of recovery to meet initial investment costs.

SUMMARY OF LIFE-CYCLE COST ANALYSIS: **Total CINT Smart Lab**

PROJECT IDENTIFICATION

Project Name:	103849
Fiscal year:	2019
Location:	TA-03-1420
Base Date (BD):	7/24/2019
Service Date (SD):	12/17/2019
Design feature to be Evaluated:	HVAC and lighting renovation
List Constraints:	0
Energy/Water Conservation Study? (FEMP)	Yes

BASE CASE AND ALTERNATIVES

Name and describe base case and alternatives to be analyzed. Include any relevent assumptions:

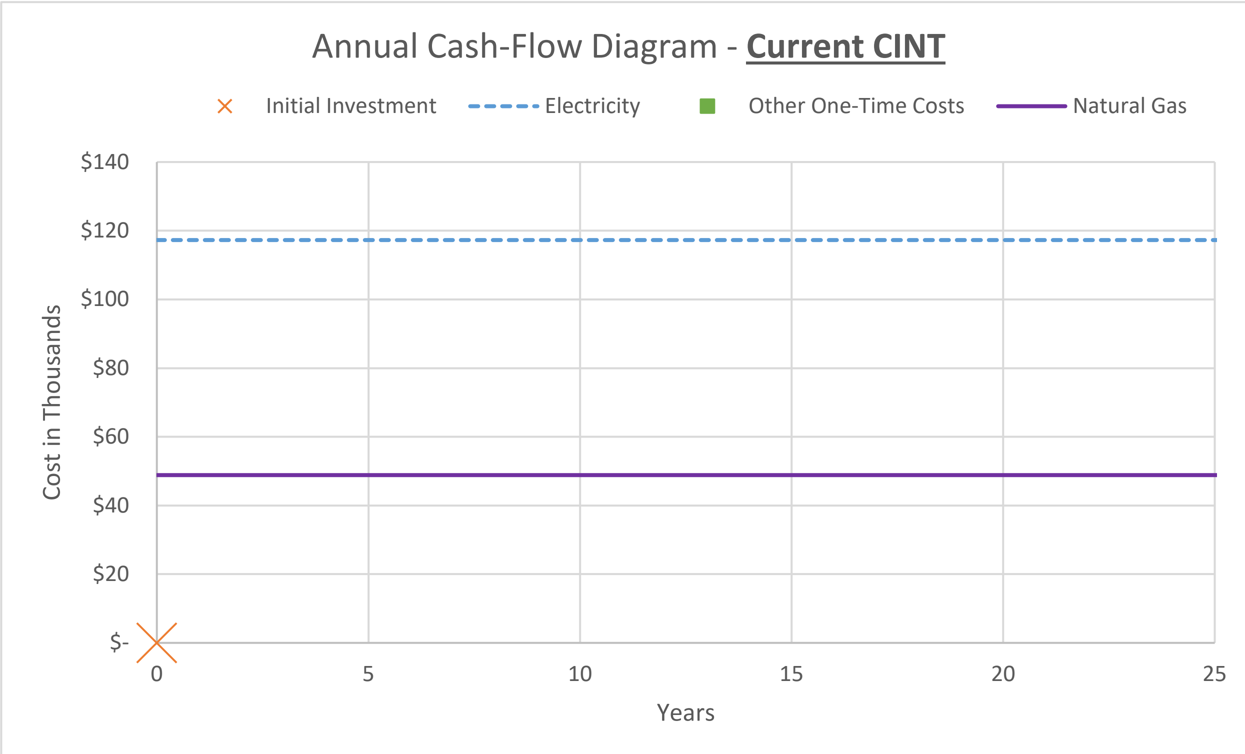
Comparing if the Smart Lab renovaiton should be implemented at CINT.

GENERAL INFORMATION:

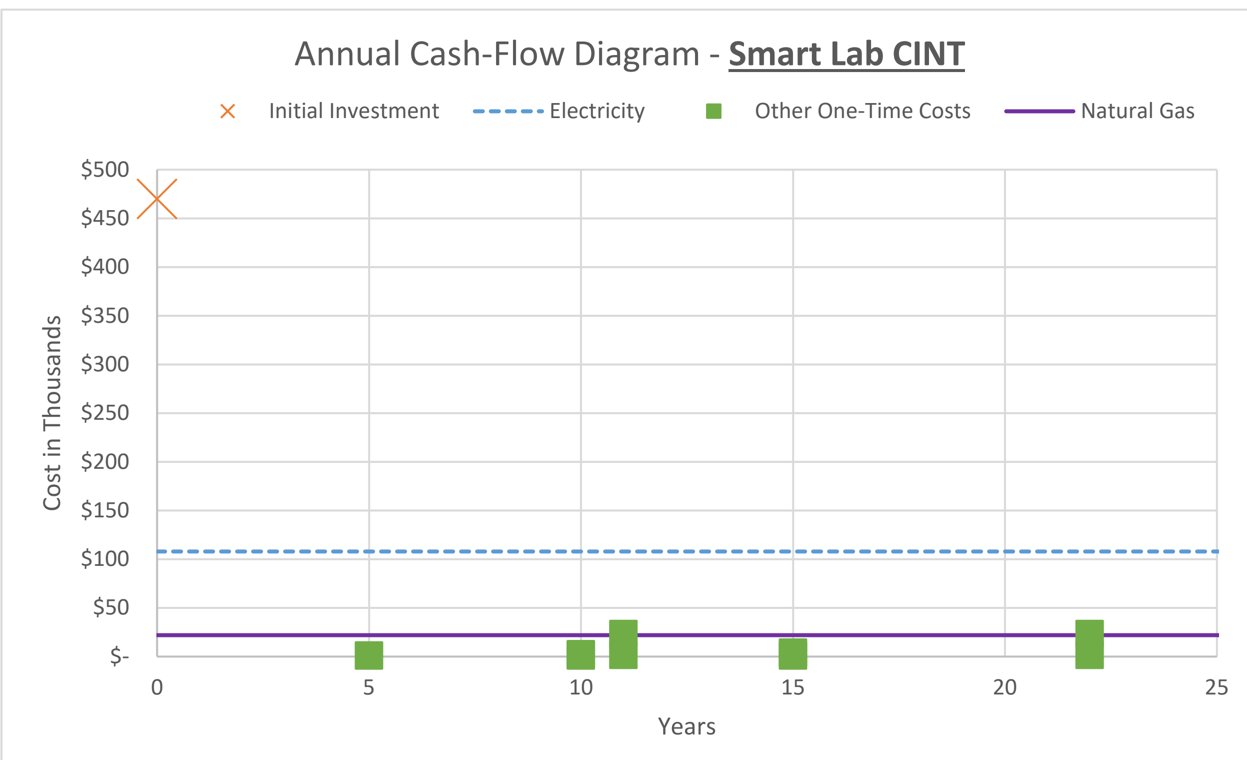
Name of Analyst:	Matney Juntunen
Phone Number:	55-667-1975
Z-Number:	341830
Date of Study Completion:	8/2/2019

KEY DATES

Years of Life:	25
BD:	7/24/2019
SD:	12/17/2019
End of Study:	8/2/2019



<u>Current CINT</u> Present Value Life Cycle Costs: $ 186.07



Total <u>Smart Lab</u> Present Value Life Cycle Costs: $ 633.33

SAVINGS-TO-INVESTMENT RATIO:

Savings-to-Investments Ratio (SIR):	0.0777

DISCOUNT PAYBACK PERIOD: FEMP

Discount Payback Period:	10
Fiscal year of Discount Payback:	2029

A.8 STUDENT SYMPOSIUM POSTER

Smart Labs Renovation in TA-03-1420

Adam Collins, Matney Juntunen, Julianne Sanscartier, Troy Sims, Jacob Torrez

Smart Lab Components

BAS
- Fundamental platform of dynamic, digital control systems
- Commissioning with automated cross platform fault detection

HVAC
- Demand based ventilation
- Exhaust fan discharge optimization
- Pressure drop optimization
- Fume hood flow optimization

LIGHT
- Low power density, demand based lighting

Initial Conditions

- Two air handling units run co-dependently
- Space available for energy recovery system (ERS)
- T8 lamps and inefficient zoning
- Motion sensors installed in office spaces
- Office and lab spaces run at similar air changes per hour (ACH)
- Building automation system continually adjusts air conditions for efficiency (see Figure 1)

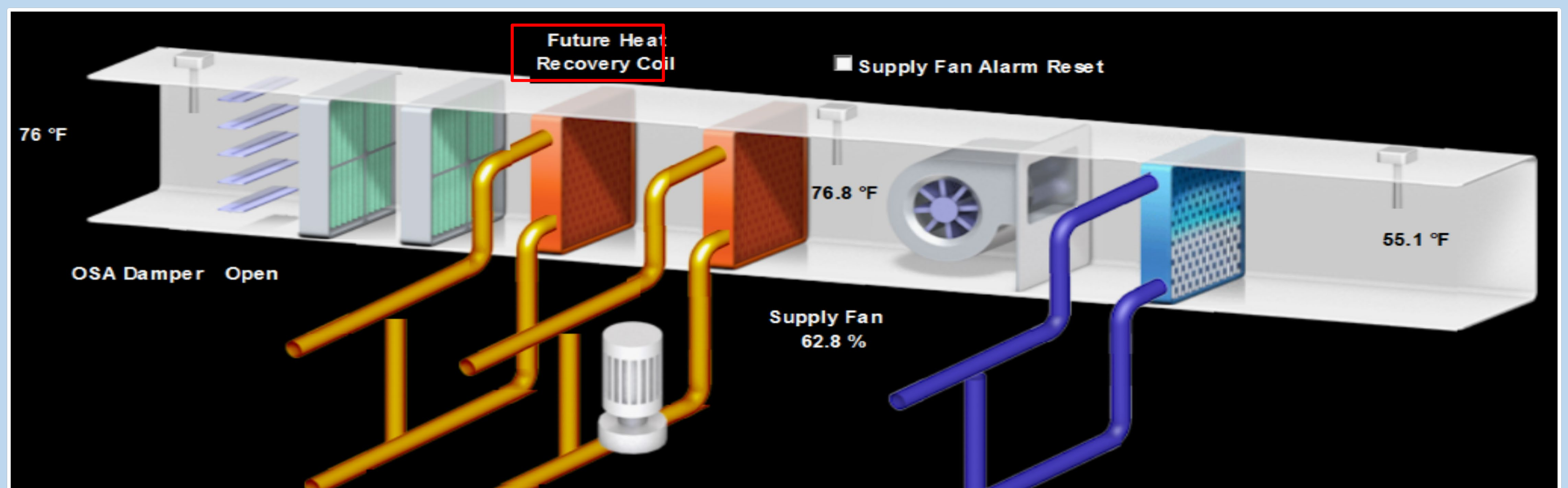


Figure 1: Building Automation Interface for AHU-1

Further Design Recommendations

- Laboratory chilled water system to decrease equipment heat load
- Laboratory risk/chemical banding to optimize air flow conditions and improve safety
- Random fume hood inspections to decrease clutter and turbulence in work space
- Reconfigure BAS to Automated Logic to gain control of Phoenix valves

LA UR 19 -

Acknowledgements

Special thanks to Steve Renfro, Lynne Knight, Monica Witt, Genna Waldvogel, Sonia Ballesteros, Joe Klose, Scottie Richardson, Jeff Fredenburg, Kent Brown, Derrick Christian, Erik Causey, Stuart Rector, George Hrbek, and many more.

Abstract

Center for Integrated Nanotechnologies (CINT) is a world class leader in innovation of nanostructured materials, however its 21st century building does not meet its potential in efficient energy use and safety. Therefore, LANL and Department of Energy have set energy savings goals as an important mission. Our solution utilizes UC Irvine's Smart Lab design to facilitate newfound energy efficiency at LANL. Through the use of Smart Lab's seven key components, we will help upgrade the energy efficiency, safety, and working environment of the CINT lab spaces.

Total Cost Savings

22%

Total Energy Savings

44%

Total Payback
10 years

SAFETY
- Decrease fume hood turbulence to reduce laboratory energy demand
- Controlled air flow and sash alarm increases tenant safety

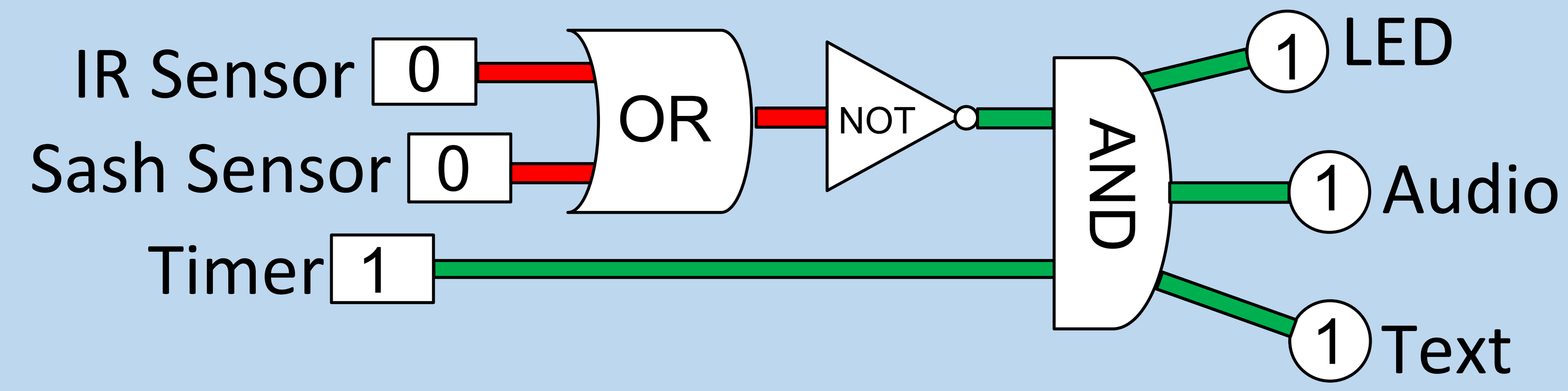
HVAC
- Office/corridor setbacks (air changes and temperature) decrease energy demands
- Energy recovery system optimizes excess heat or cooling exiting the building

LIGHT
- Occupancy sensing LED lighting in every room decreases electrical demand
- Savings-to-investment ratio of 6.29

Upgrades to TA-03-1420

Fume Hood Sensor Prototype

- IR sensor to determine occupancy
- Potentiometer to check sash height
- Automated Logic Circuit system
- Sets off visual, audio, and text alarms



HVAC System

- Separate air handling units to regulate ACH and temperature in laboratory, office, and other spaces
- Maintain pressure differential in lab and office spaces using rubber gaskets
- Install an energy recovery system (ERS) to reuse energy by capturing it and using that energy to pre-heat or pre-cool the outdoor airstream (See Figure 2)

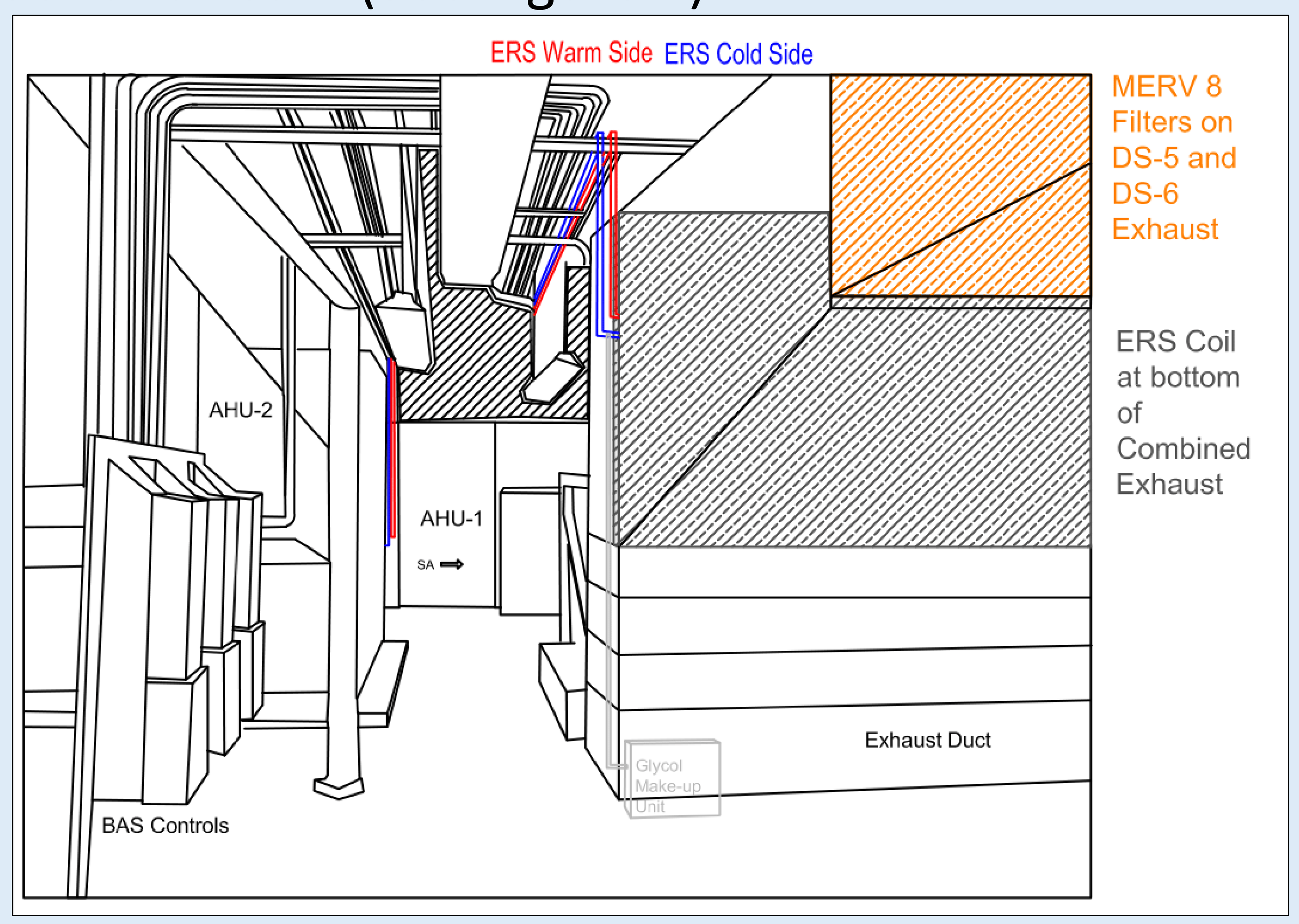


Figure 2: Energy Recovery System Location – Second Floor Mechanical Room

Lighting System

- T8 to LED
- Rezone Lighting
- IR Sensors in Corridors

Present Value Savings:	$744,750
Discounted Payback Period:	3 years

LOS ALAMOS NATIONAL LABORATORY

A.9 FINAL TEAM PRESENTATION

ALDCP 2019 Student Team Final Briefing: CINT Smart Lab

Final Smart Lab Briefing

Adam Collins, Matney Juntunen,
Julianne Sanscartier, Troy Sims, Jake Torrez

August 7th, 2019

UNCLASSIFIED

Managed by Triad National Security, LLC for the U.S. Department of Energy's NNSA

LA-UR-YY-XXXXX

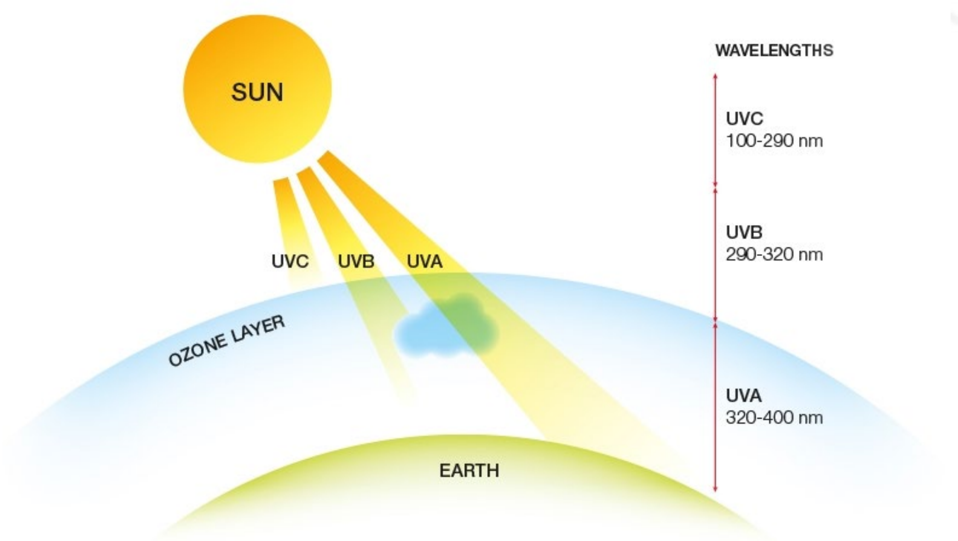
Presentation Overview

Please save questions for the end of the presentation.

UVC
- Doesn't Penetrate Ozone Layer

UVB
- Reaches skin's surface
- Tanning, burning, aging.

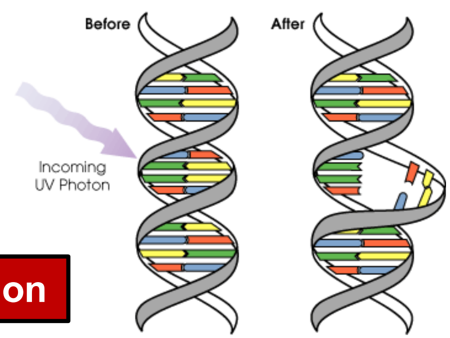
UVA
- Penetrate deep in skin
- Causes DNA changes, skin cancer



Risks:
- Sunburn
- Eye Irritation
- Skin Cancer
- Blindness

Victims:
- Outdoors for long periods of time.

Protection:
- Sunscreen (every two hours)
- Sunglasses
- Limit exposure



90% of nonmelanoma skin cancer is from UV radiation

Stay inside, don't get fried!

Better Buildings®
U.S. DEPARTMENT OF ENERGY

What is a Smart Lab?

HVAC

LIGHT

BAS

Smart Labs aims to reduce energy usage and increase safety for laboratories.

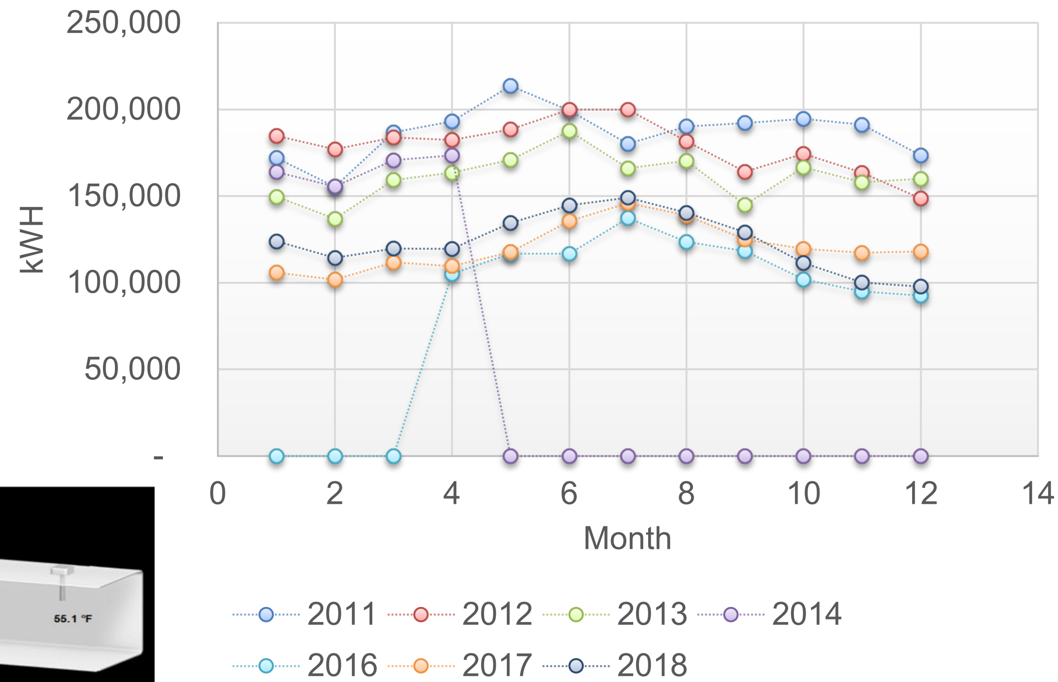
TA 03-1420

- **Generate an optimized Smart Lab design package to reduce CINT energy demand and increase overall health, safety, and productiveness.**
- **Project ID, PRID, RCD, RPA, Cost/Estimate, Schedule, Symposium Poster**

We are aiding the implementation of the Smart Lab initiative at LANL.

- 2 air handlers run co-dependently
- Space available for energy recovery system (ERS)
- CINT uses T8 fluorescent lights and inadequate zoning
- Office motion sensors
- Office and lab spaces running at similar air changes per hour
- Building automation system in place

TA 03-1420 Electric Report Card



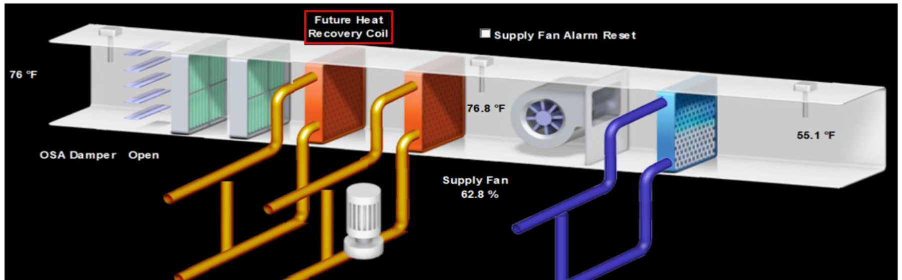


Figure 1: Building Automation Interface for AHU-1

Total Energy Cost: $166,00.00

CINT has potential to reduce energy usage.

Smart Lab Student Design Process

1. Preliminary Research
   Develop Scope
2. Building Walkthroughs
   Identify Problems
3. Brainstorm Solutions
   Numerical Analysis
4. Design Solutions in AutoCAD
   Check and finalize solutions with SMEs
5. SOW
   RCD
   PRID
   Mission Needs
6. Project Estimation
   Construction Schedule
7. Life Cycle Cost Analyses
   Construct Prototype
8. Final Presentations
   Submit written recommendation

Our design process was determined in detail at the start of our project.

Design Proposal Areas

- (untitled)
  - Energy recovery system
  - Independent air handling units
- **Lighting**
  - LED bulbs in all rooms
  - IR occupancy sensors
- **Laboratory Air/Safety**
  - Chemical/Risk banding
  - Chilled Water System
- **Prototype**
  - Fume hood sash alarm
  - Safety

These Smart Lab components will save the most amount of energy.

HVAC Overview

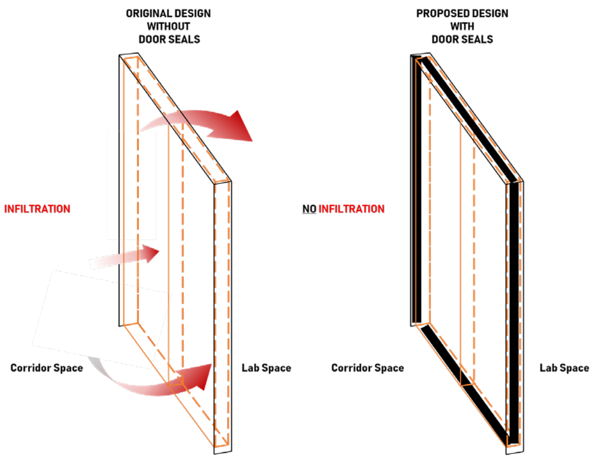
Separate
Air Handling Units (AHU)

HVA-1 Load (Lab)

HVA-2 Load (Office)

+

Air Changes



- Reduce air changes in non-biohazard or chemical hazard labs to 6 per hour
- Reduce air changes in office, corridor, and break spaces to 5 per hour
- Temperature and occupancy setbacks in offices/corridors

Independent units allows the BAS to regulate ventilation, thus saving energy.

HVAC: Independent Air Handling Units

HVAC Load Calculations

Based on 1997 ASHRAE Handbook CLTD/SCL/CLF Method

Project:	HVU2 Heat Calcs - No lab infiltration, All LED Lights	
Project No.:		
Date:	July 8, 2019	
Calcs By:	Matney Juntunen	
Block or Terminal Loads		

INPUT

General Data

Project Location:	TA-03-1420	
Project Latitude:		deg. N.
Weather Data Source	2017 ASHRAE Handbook of Fundamentals, Chapter 14	
Summer Criteria	1.0	% Occurance
Winter Criteria	99.6	% Occurance
Safety Factor - Cooling	0	%
Safety Factor - Heating	25	%
System Description	Offices and Cooridoors	
Summer Outside Design Temerature	89	degF
Inside Summer Design Temperature	78	degF (Default value)
Summer SA Temperature	55	degF
Winter Outside Design Temerature	5	degF
Inside Winter Design Temperature	72	degF (Default value)
Max. Winter SA Temperature	95	degF
Min. SA Airflow Percentage	30	%
Infiltration - Air Change Method	0.25	Air Changes/Hr
Infiltration - Air Leakage Method	0.05	CFM/sf of Wall/Glass surface
People - Sensible Heat	250	BTU/Hr/ Person
People - Latent Heat	160	BTU/Hr/ Person

HVA2 Summer

Total 1st Floor Cool Demand:	162,305	BTU/Hr
Total HVU2 Cool Demand:	234,739	BTU/Hr
Total HVU2 Cool Demand:	12,361.17	CFM

HVA2 Winter

Total 1st Floor Heat Demand:	-26,364	BTU/Hr
Total HVU2 Heat Demand:	-48,857	BTU/Hr
Total HVU2 Heat Demand:	(482.11)	CFM

HVA2 Spring/Fall	92,941	BTU/Hr
	6,422	CFM

Cooling

Summer Dry bulb (F):	89	Summer MA change in enthalpy: HVA2	
Summer Relative Humidity:	30%	Inside temp:	75
Summer design temp indoors:	75	Outside temp:	89
Summer Delta Enthalpy:	4.22	MA temp:	77.1
		Change in enthalpy:	-1.2

Heating

Winter Dry bulb (F):	5	Winter MA change in enthalpy: HVA2	
Winter Relative Humidity:	30%	Inside temp:	72
Winter design temp indoors:	72	Outside temp:	5
Winter Delta Enthalpy:	22.52	MA temp:	61.95
		Change in enthalpy:	4.6

BTU/Hr = CFM*4.5*deltaenthalpy

Office
Conference
Min. Ventilation
Hall/Corridor

Room Data	**Room Description**	1 dt, 2 ppl	2 dt, 2 ppl	3 dt, 3 ppl	1 dt, 2 ppl	1 dt, 2 ppl	1 dt, 2 ppl	6 ppl, 1 tv	Copy/print, telecom, elec	3 dt, 3 ppl	Showers and Toilets	Storage	Break Room	Kitchenette	Bathroom
Room No.:		**1102**	**1102A**	**1104**	**1106, 1108, 1110, 1112**	**1111, 1113, 1115,1117**	**1116, 1118**	**1126**	**1120, 1122, 1124**	**1302, 1304, 1306**	**1300A, 1310,1312, 1316, 1314**	**1318, 1324**	**1123**	**1322, 1320**	**1212, 1214**
Room Name:															
Peak Cooling Month		7	7	7	7	7	7	7	7	7	7	7	7	7	7
Peak Cooling Time		1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400	1400
Summer Inside Temp (°F)		78	78	78	78	78	78	78	78	78	78	78	78	78	78
Winter Inside Temp (°F)		72	72	72	72	72	72	72	72	72	72	72	72	72	72
Safety Factor - Summer (%)		0	0	0	0	0	0	0	0	0	0	0	0	0	0
Safety Factor - Winter (%)		25	25	25	25	25	25	25	25	25	25	25	25	25	25
Room Width (ft)															
Room Length (ft)															
Room Height (ft)		9	9	9	9	8.5	9	9	9	9	8.8	9	8	8	9
Room Floor Area (sf)	4,588	108	129	217	509	720	240	196	296	674	409	210	368	169	343
Room Volume (ft^3)	40,313	972	1,161	1,953	4,581	6,120	2,160	1,764	2,664	6,066	3,599	1,890	2,944	1,352	3,087

Figure 2: ASHRAE Heat Load Calculations Example

- – Assumed no lab infiltration
- – Assumed all LED lights
- – Used initial system design
- – Used LANL Standards

- Design energy conclusions:
  - – Thermal savings

CINT's HVAC system is compatible with our design ideas.

HVAC: Energy Recovery System

- Supply and exhaust cross-flow heat exchangers
- 110 LF of copper tubing
- MERV8 Filters
- 460V pump
- 50% glycol-water mix refrigerant

Class 4 Estimate: ~$290,000

Energy Cost Savings: $3,700 / year

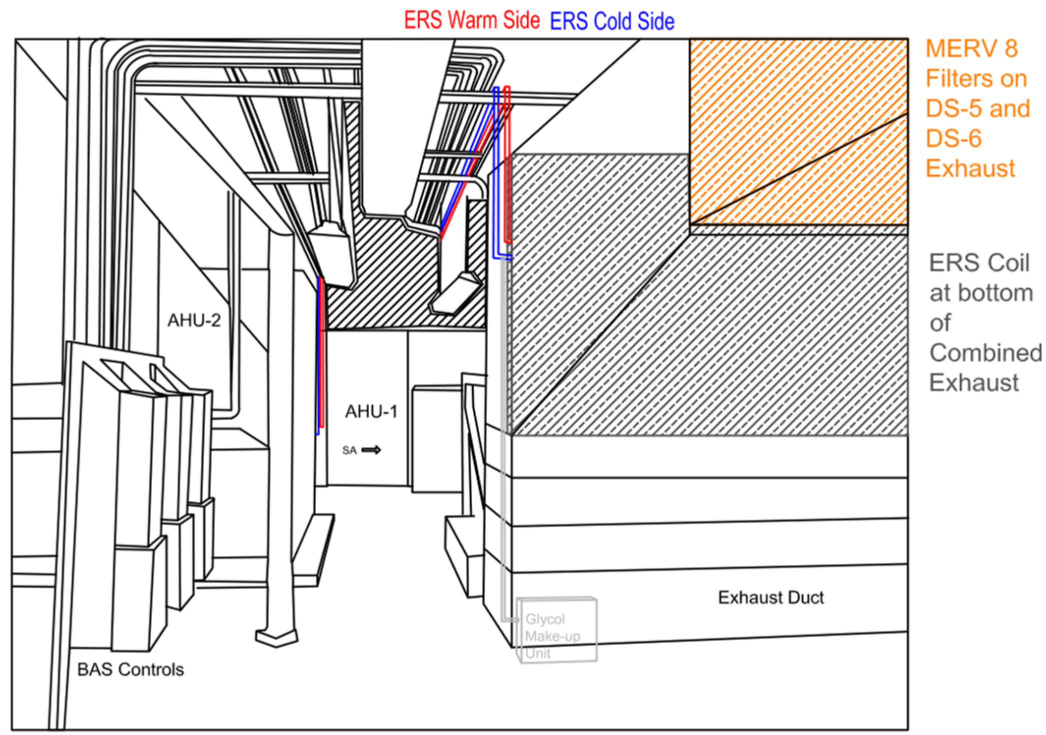


Photo Credit – Adam Collins

HVAC optimization is the largest source of energy savings.

Laboratory Ventilation Optimization

Once lab doors are sealed and office ACH setbacks are made:

- ES&H ventilation Assessment
- Determination of Labs that can experience reduced Air Changes
- Changes to set points made using BAS

ECT, Inc. - ChemGEN - Chemical Accumulation-Dilution Calculator

Air Temperature - dF	Fahrenheit Temp	Temp Kelvin	Temp. C
	72	295.4	22.2

Pressure = mm Hg	mmHg	kPa	Pa
	760	101	101325

Room or Enclosure Dimensions	Length - ft	Depth - ft	Height - ft	Area - ft2	Volume - ft3	Volume - liters	Volume - m3
	10	28	10	280	2800	8.E+04	79.30

VEFF (0.5 to 2)	1	Q' Percent	100%

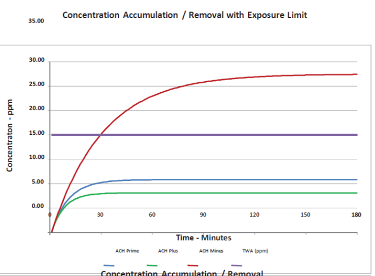
Airflow & Concentration

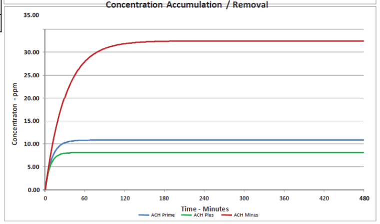
	ACH					ppm			
ACH PRIME	280	280	6.0	6.0	1	10.9	10.83	10.83	608
ACH PLUS +	2	373	8.0	8.0	1.3	8.2	8.12	8.12	588
ACH MINUS -	4	93	2.0	2.0	0.3	32.8	32.48	32.48	781

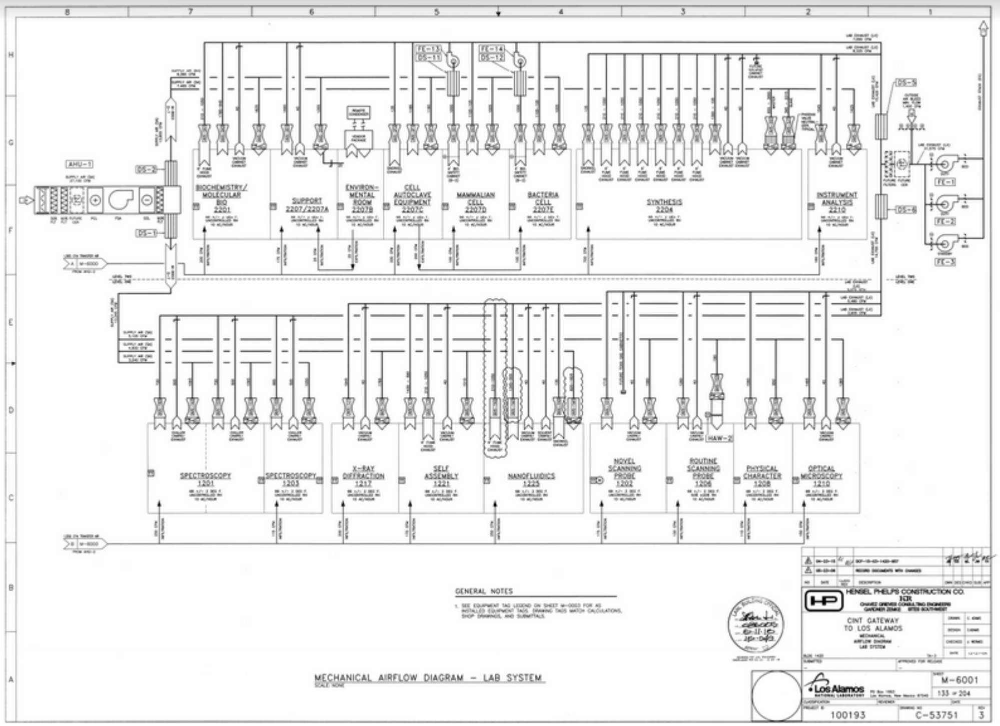
Choose Chemical	Acetonitrile							
Quantity - ml	100	Surface Area - sq cm	Surface Area - sq. m	Gen Rate - lpm	Gen Rate - g/min	Time to Evap - minutes	TWA (ppm)	VHR
Select Scenario	Multiple Sources							
Exposed Surface Diameter- cm	12	113.1	0.01131	0.087	0.1467	539	20.00	4803

Air Velocity over Chemical	fpm	m/s
	30	0.15

Process Temperature	Degrees C	Degrees K	Vapor Pressure - mm Hg
	22	295	83







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NNSA National Nuclear Security Administration

Laboratory Ventilation Cost Analysis

With the average total Lab Air changes now at 8.70 ACH (4 labs reduced to 6 Air Changes)

Project Cost:

- ES&H testing: $70,000 if not done during regular testing cycle
- BAS and TAB changes: $12,000

Project Savings:

- HVA-1 Fan Savings in Labs of 0.264 KW/h
- HVA1-2 Fan Savings of 4.825 KW/h
- Yearly Savings of $3,381.36

- Project paid back in 3.5 years if the ES&H testing is done within regular cycle.
- $4,700 yearly savings if average total Air Changes reduced to 7 per hour.

HVAC Results

Category	Annual Savings
ERS (Thermal and Electric)	$ 3,712.67
	876 MMBTU
Air Change Setbacks (Thermal)	$ 24,482.49
	7,310 MMBTU
Total HVAC Changes:	**42%** **Energy Savings**
Total Discounted Payback Period: (25 Year Lifetime)	**9 Years**

HVAC optimization is the largest source of energy savings.

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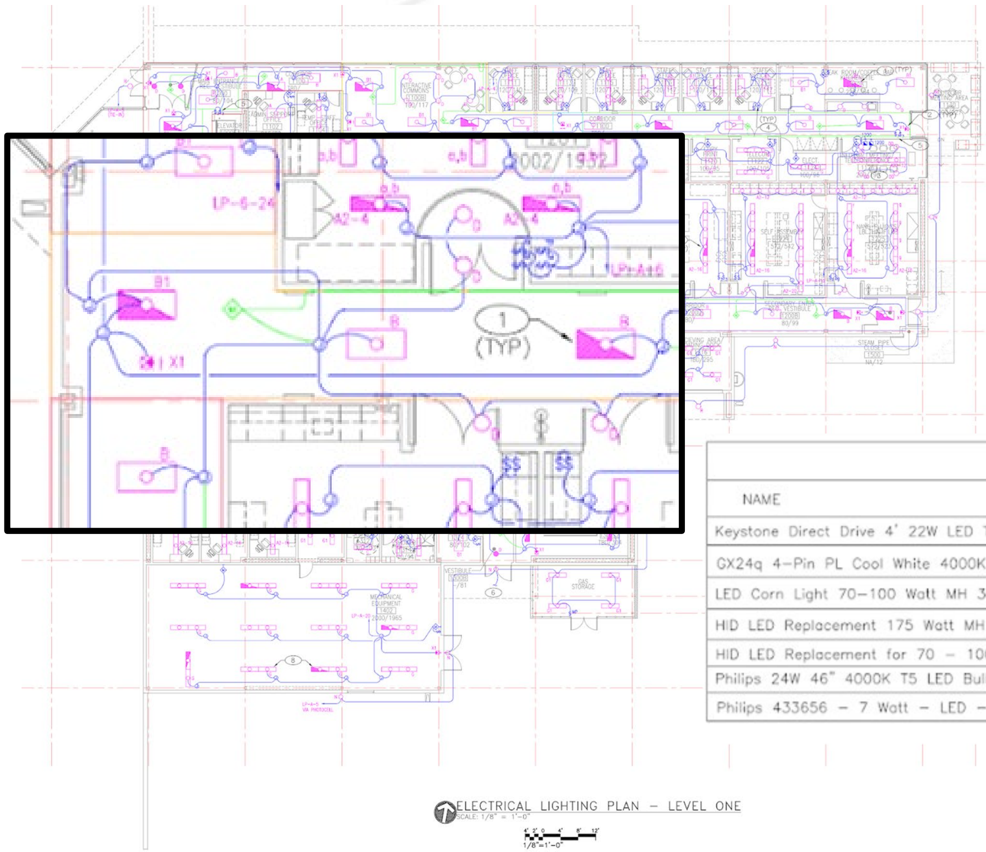
Illuminance Calculations	
$lx = \frac{lm}{A}(CU)$	$lx = lux$ $lm = lumens$ $A = area\ (square\ meters)$ $CU = Coefficient\ of\ Utilization$
IES Standards for Illuminance	
Corridors	236-291 lux
Offices	387-474 lux
Labs (similar to	387-474 lux
IES Standards for Power Allowance	
$PA = A(LPD)$	$A = area\ (square\ feet)$
Office LPD	0.79 W/ft[2]
Lab LPD	1.45 W/ft[3]
Lobbies LPD	1.00 W/ft[4]
Corridors LPD	1.00 W/ft[5]
Light Loss Factor Calculations	
LLF = RSDD(LDD)(BF)(LLD)	
LLF = Light loss factor	
RSDD = Room Surface Dirt Depreciation	
LDD = Luminaire dirt depreciation	
BF = Ballast Factor	
LLD = Lamp Lumen Depreciation	
T-8 Lamps	**LED Lamps**
BF = 0.88	BF = 1.00
LLD = 0.95	LLD = 0.875
LDD = 0.98	LDD = 0.98
RSDD = 0.7	RSDD = 0.7
LLF = .573	**LLF = .6**

Lighting Calculations

Area of TA 03-1420	Fixtures+	# of lamps+	lumens per lamp+	total lumens+	Area of room (square meters)*	Area of room (square feet)*	Power Allowance +	Illuminance+	General CU+	Total Power+	Lamp Type Fixture Type+	Total Power In Building
2210 - Lab Space*	2	24	2600	62,400	48.03	517	2758	389.756402	0.3	624	KS LED T8 A2-16	2040
2105 - Office Space*	2	6	2600	15,600	11.98	129	2758	390.651085	0.3	156	KS LED T8 A1	2040
1206 - Lab Space*	1 1 1	36	2600	93,600	48.03	517	2758	584.634603	0.3	936	KS LED T8 A2-16 A2-20 A2-12	2040
1111 - Office Space*	2	6	2600	15,600	11.15	120	2758	419.730942	0.3	156	KS LED T8 A1	2040
1200A - Corridor Space*	3	6	3500	21,000	24.71	266	2758	254.957507	0.3	168	LED T5 B	2040

* = reference to TA 03-1420 floor plans, + = reference to revised lighting schedule

Lighting Analysis meets standards and requirements.



Class 3 Estimate: ~$142,000

Payback Period: 3 years

Energy Cost Savings: $5,270 / year

Maintenance Cost Savings: $35,000 / year

BILL OF MATERIALS

NAME	QTY	PRODUCT ID	UNIT COST	ABB.
Keystone Direct Drive 4' 22W LED T8 Tube	1,074	LT8xxK22WCG-K	$11.95	KS LED T8
GX24q 4-Pin PL Cool White 4000K	64	PL10H/841/BYP/LED 81145	$16.42	GX24 LED
LED Corn Light 70-100 Watt MH 3000K E26	6	CL-HL-18W-30K-E26	$27.00	18W E26
HID LED Replacement 175 Watt MH 3000K E39	7	CL-36-30K-E39	$42.25	36W E39
HID LED Replacement for 70 - 100 Watt HPS 3000K	1	27HID/830/277V/EX39	$48.23	27W HID
Philips 24W 46" 4000K T5 LED Bulb	205	24T5 LED/48-4000 IF	$14.89	LED T5
Philips 433656 - 7 Watt - LED - MR16	2	7MR16/F36 3000 DIM HO 10/1	$11.75	7W MR16

Lighting payback period is 3 years

Smart Lab Annual Overview

Current CINT Energy

- $166,000
- 19,700 MMBTU

Smart Lab Energy Savings

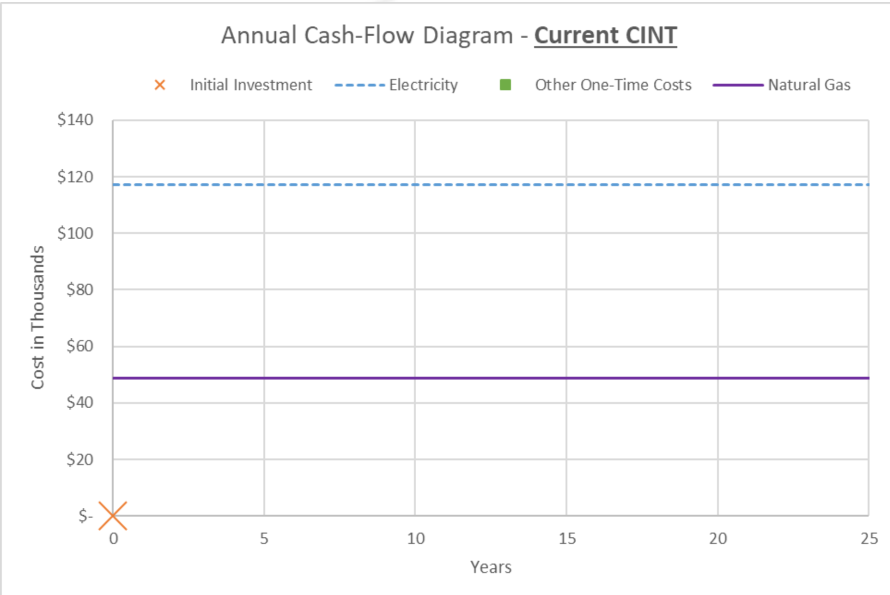
- 8,554 MMBTU
- 44%

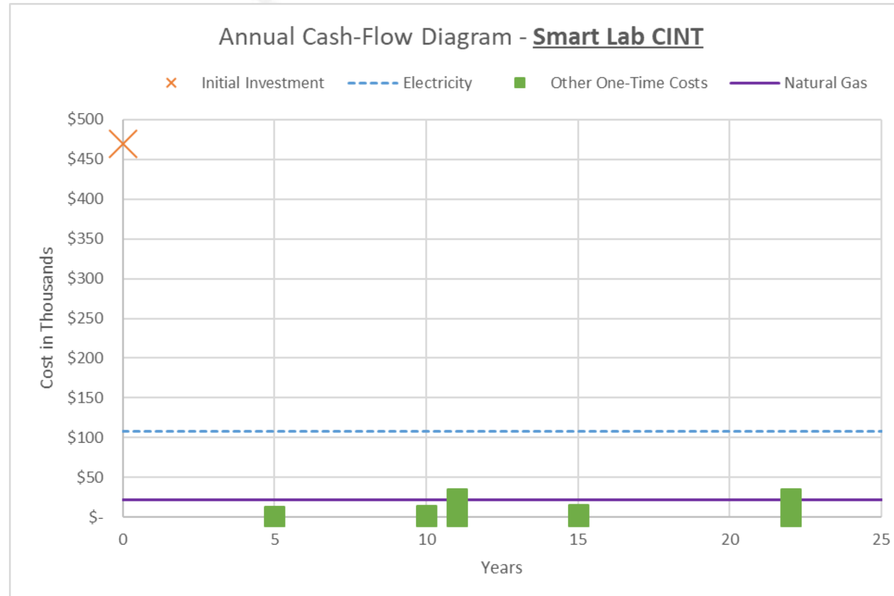
Smart Lab Cost Savings

- $36,800
- 22%

The CINT Smart Lab will reduce energy demand by approx. 44%

CINT Smart Lab Life-Cycle Cost Analysis





Smart Lab Present Value
(25 years): $633,300.00

Discounted Payback Period: 10 Years

The life-cycle cost analysis proves our designs to be cost effective

Projected Cost Estimation

Category	Initial Cost
ERS (Materials, Labor, and TAB)	$290,000.00
Air Handling Unit Changes/Setbacks (Labor and TAB)	$34,000.00
Lighting (Materials and Labor)	$145,000.00
Total Initial investment:	**$469,000.00**

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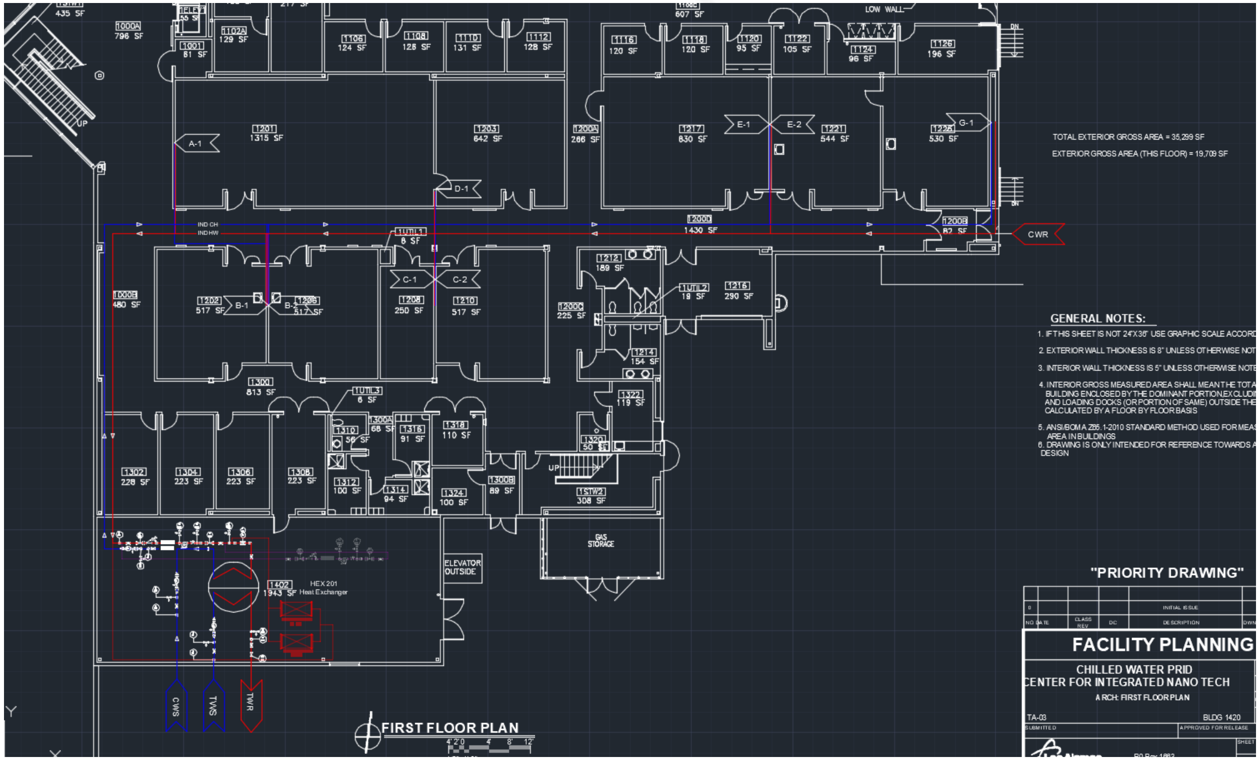
Chilled Water System

Projected Accomplishments:

- Reduces extraneous heat produced by lab equipment and portable chillers.
- Allows for better temperature consistency
- HVA-1 Supply air can be reduced by 5,500 CFM due to reduced cooling load
- 1.18 KW/h can be saved using this system (10,300 KW per year)



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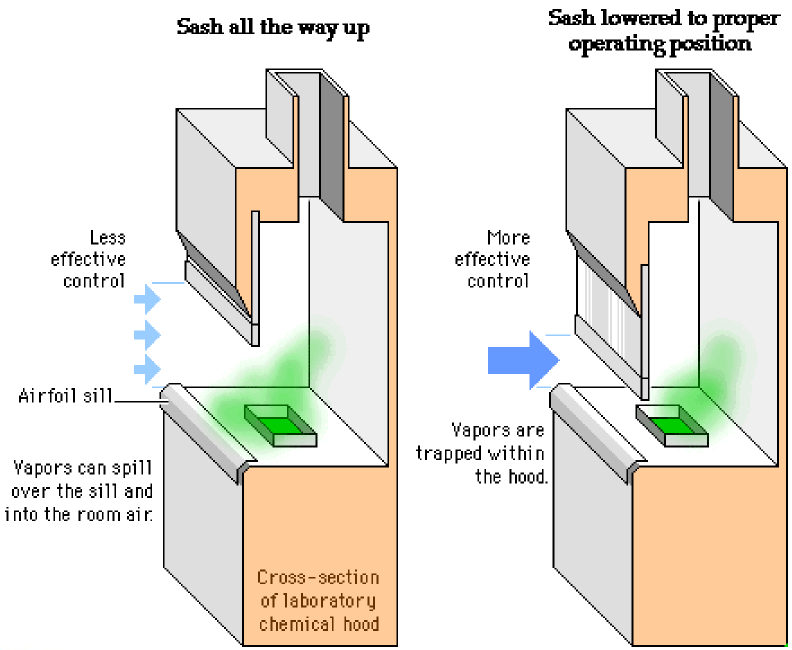
Hood Inspections

Random Hood Inspections and Sash Police Ensure:

- Sashes are lowered as much as possible during work and when not in use
- Hoods are always kept clean and free of excessive clutter/turbulence



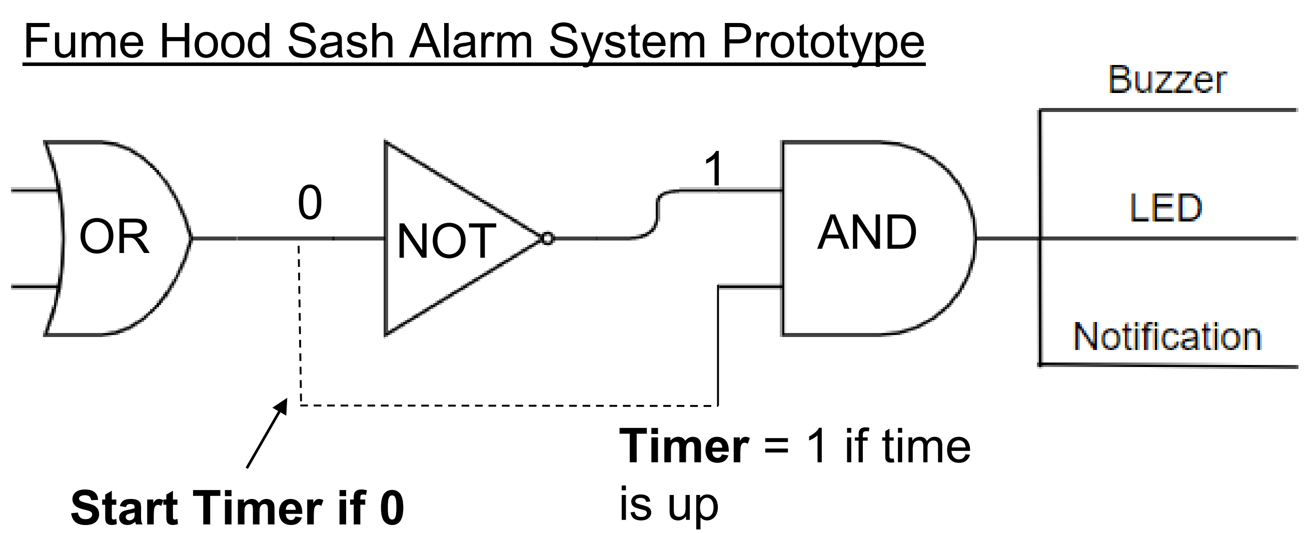
Risk Banding

Risk banding chemicals and processes provides:

- Increased safety for scientists, especially in a nanotechnology lab
- Ensures certain chemicals or processes are only occurring in areas with proper ventilation
- Can be incorporated into the safety culture of the lab

Risk Control Band	Description
0	Negligible
1	Low
2	Moderate
3	High
4	Very High
5	Extreme

Project Prototype



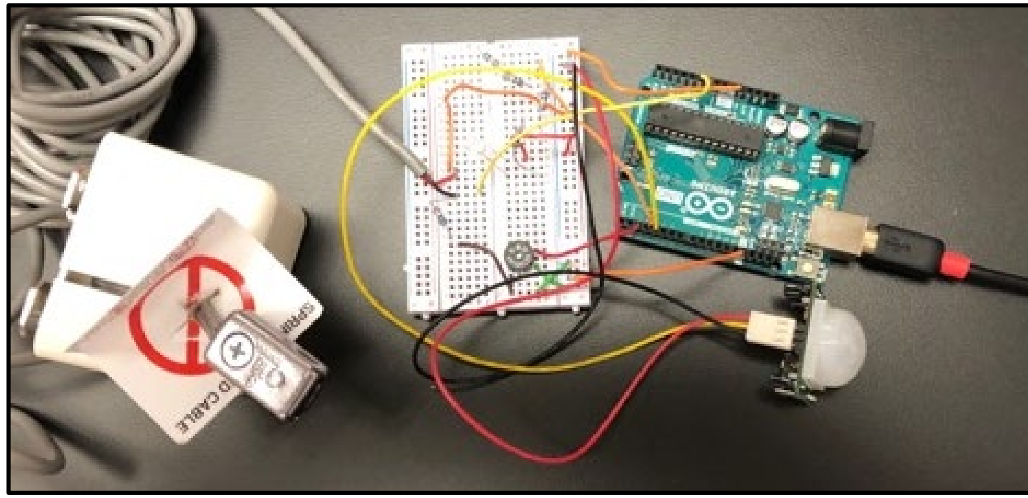
Funding:
BAS & INNO-ASUR

Construction:
BAS Lab Space

Prototype will help increase tenant safety and reduce energy usage.

Project Prototype

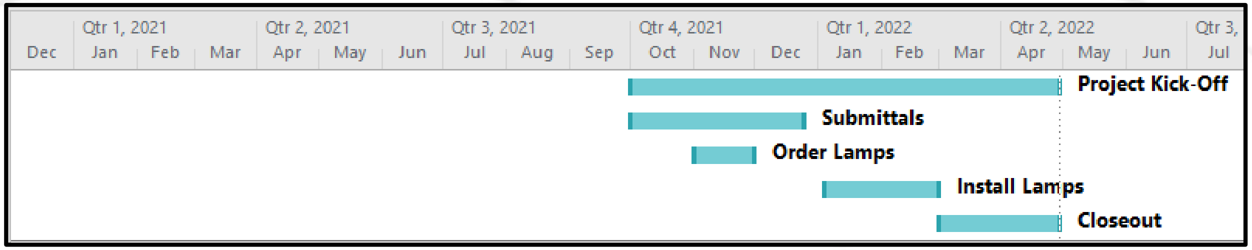
```
  pinMode(led_pin, OUTPUT);
  pinMode(pir_pin, INPUT);
  delay(2000);
}

void loop() {

  while (clicker < 1000) { /* Keep looping as a timer */
    data = check_data(); /* Checks data */
    delay(10); /* 500ms delay */
    if (data == 1) {
      digitalWrite(led_pin, HIGH);
      clicker++;
    }
    else {
      digitalWrite(led_pin, LOW);
      digitalWrite(notification_pin, LOW);
      clicker = 0;
    }
  }

  check = 1;

  while (check == 1) { /* check is True */
    data = check_data(); /* Check data */
    if (data == 1) {
      alarm();
    }
    else {
```



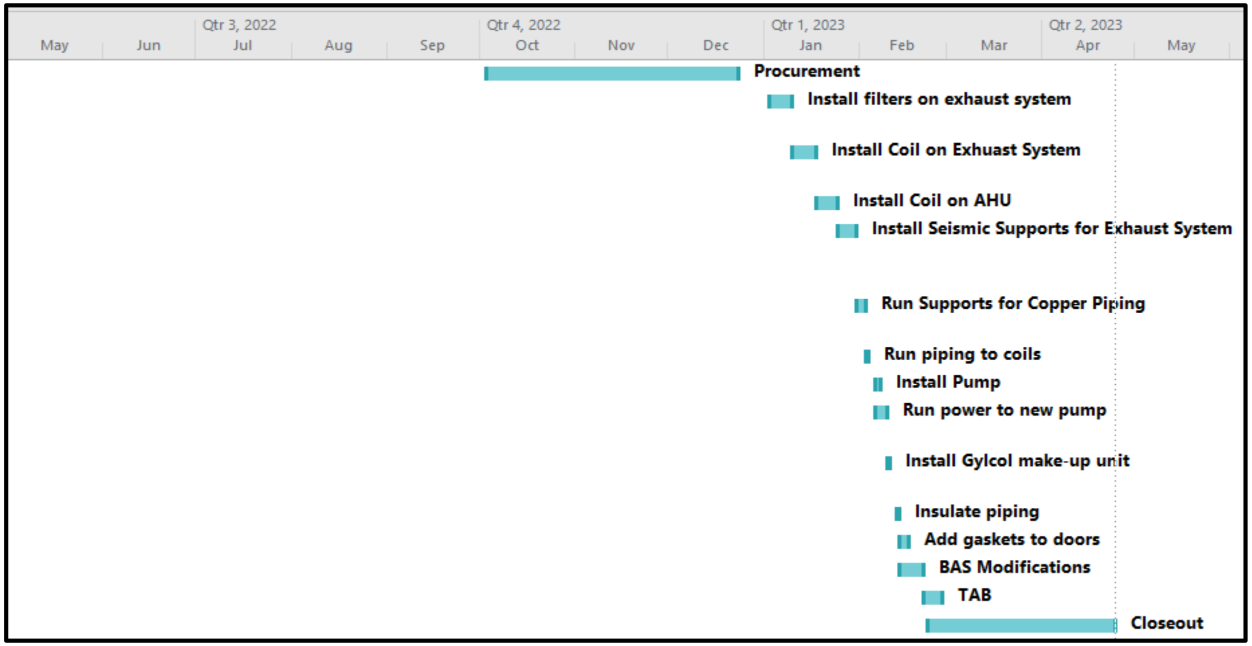
Example of the code written and hardware for the prototype.

Construction Schedule

Lighting Schedule
- October 2021 – April 2022



HVAC Schedule
- October 2022 – April 2023



Final Poster

Smart Labs Renovation in TA-03-1420

Adam Collins, Matney Juntunen, Julianne Sanscartier, Troy Sims, Jacob Torrez

Smart Lab Components

BAS
- Fundamental platform of dynamic, digital control systems
- Commissioning with automated cross platform fault detection

HVAC
- Demand based ventilation
- Exhaust fan discharge optimization
- Pressure drop optimization
- Fume hood flow optimization

LIGHT
- Low power density, demand based lighting

Initial Conditions

- Two air handling units run co-dependently
- Space available for energy recovery system (ERS)
- T8 lamps and inefficient zoning
- Motion sensors installed in office spaces
- Office and lab spaces run at similar air changes per hour (ACH)
- Building automation system continually adjusts air conditions for efficiency (see Figure 1)

Figure 1: Building Automation Interface for AHU-1

Further Design Recommendations

- Laboratory chilled water system to decrease equipment heat load
- Laboratory risk/chemical banding to optimize air flow conditions and improve safety
- Random fume hood inspections to decrease clutter and turbulence in work space
- Reconfigure BAS to Automated Logic to gain control of Phoenix valves

LA UR 19 -

Acknowledgements

Special thanks to Steve Renfro, Lynne Knight, Monica Witt, Genna Waldvogel, Sonia Ballesteros, Joe Klose, Scottie Richardson, Jeff Fredenburg, Kent Brown, Derrick Christian, Erik Causey, Stuart Rector, George Hrbek, and many more.

Abstract

Center for Integrated Nanotechnologies (CINT) is a world class leader in innovation of nanostructured materials, however its 21st century building does not meet its potential in efficient energy use and safety. Therefore, LANL and Department of Energy have set energy savings goals as an important mission. Our solution utilizes UC Irvine's Smart Lab design to facilitate newfound energy efficiency at LANL. Through the use of Smart Lab's seven key components, we will help upgrade the energy efficiency, safety, and working environment of the CINT lab spaces.

Annual Cost Savings 22%

Annual Energy Savings 44%

Total Payback 10 years

SAFETY
- Decrease fume hood turbulence to reduce laboratory energy demand
- Controlled air flow and sash alarm increases tenant safety

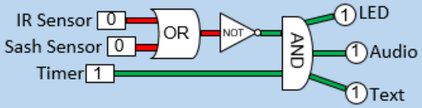
HVAC
- Office/corridor setbacks (air changes and temperature) decrease energy demands
- Energy recovery system optimizes excess heat or cooling exiting the building

LIGHT
- Occupancy sensing LED lighting in every room decreases electrical demand
- Savings-to-investment ratio of 6.29

Upgrades to TA-03-1420

Fume Hood Sensor Prototype

- IR sensor to determine occupancy
- Potentiometer to check sash height
- Automated Logic Circuit system
- Sets off visual, audio, and text alarms



HVAC System

- Separate air handling units to regulate ACH and temperature in laboratory, office, and other spaces
- Maintain pressure differential in lab and office spaces using rubber gaskets
- Install an energy recovery system (ERS) to reuse energy by capturing it and using that energy to pre-heat or pre-cool the outdoor airstream (See Figure 2)

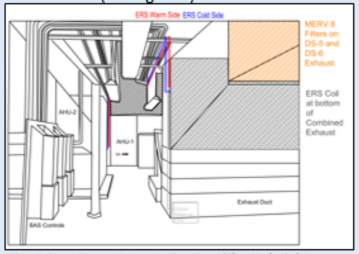


Figure 2: Energy Recovery System Location – Second Floor Mechanical Room

Lighting System

- T8 to LED
- Rezone Lighting
- IR Sensors in Corridors

Present Value Savings:	$744,750
Discounted Payback Period:	3 years

LOS ALAMOS NATIONAL LABORATORY

UNCLASSIFIED

Questions?

ALDCP Student Team 8/7/19 Briefing

Matney Juntunen

UNCLASSIFIED

Managed by Triad National Security, LLC for the U.S. Department of Energy's NNSA

LA-UR-YY-XXXXX

INDIVIDUAL PROJECTS:

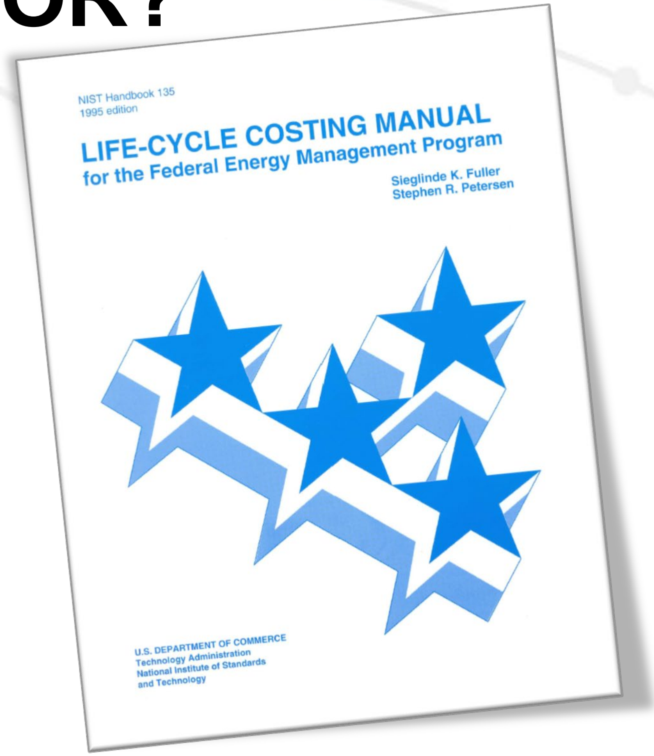
Life-Cycle Cost Analysis (LCCA) Calculator and Tests

TA-03-0223 HVAC Renovation

TA-03-0030 Renovation Feasibility Study

LCCA: WHY A CALCULATOR?

- LANL engineers struggling to commit time to thorough LCCA
- Required by Engineering Standards Manual STD-342-100
- Hand calculations are now automated and graphed, saving several hours
- Spreadsheet can be used for whole projects and components of projects



UTILITIES AND INSTITUTIONAL FACILITIES

LANL Engineers need an easier way to analyze life-cycle cost.

CALCULATOR EXAMPLE:

Cost of Gas vs. Electric LCC Analysis Calculator - See Appendix C in NIST Handbook 135 for Guidance

PROJECT IDENTIFICATION		Notes
Project Name:	Fun Project Yay	
Fiscal year:	1995	
Location:	LANL	DoE region
Base Date (BD):	5/3/2019	MM/DD/YYYY
Service Date (SD):	8/25/2022	MM/DD/YYYY
Design Feature to be Evaluated:	Energy source	
List Constraints:		Attach page if needed
Energy/Water Conservation Study? (FEMP)	Yes	(yes or no)
OMB A-94?	No	Office of Management and Budget circular?

BASE CASE AND ALTERNATIVES

Name and describe base case and alternatives to be analyzed:

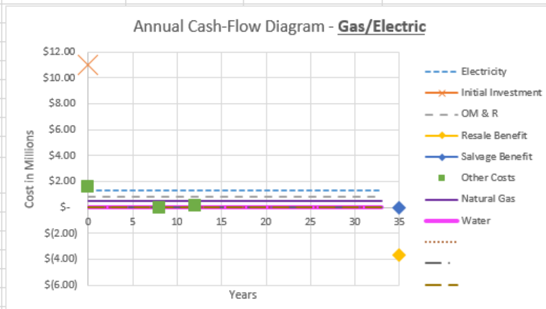
Base case is 100% electric energy, as preferred by management.

GENERAL INFORMATION:		
Name of Analyst:	Matney Juntunen	
Phone Number:	406-203-8951	
Z-Number:	341830	
Date of Study Completion:	6/12/2019	MM/DD/YYYY

KEY DATES		Notes
Years of Life:	35	Quantity (commonly 35 years)
BD:	5/3/2019	
SD:	8/25/2022	
End of Study:	6/12/2019	

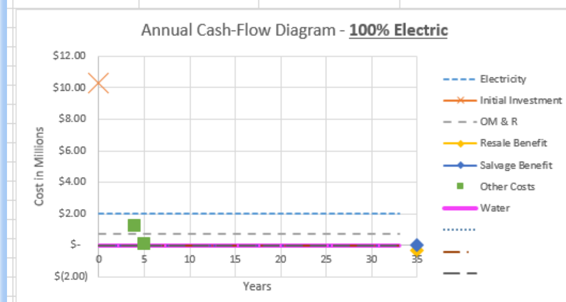
CASH FLOWS (IN MILLIONS) FOR GAS/ELECTRIC

CATEGORY	YEAR # IN LIFETIME	COST PER YEAR	Notes
Initial investment:	0	$ 11.00	
Total Electricity:	all	$ 1.30	(Usually $0.08 per kW/h)
OM & R:	all	$ 0.80	
Total Natural Gas:	all	$ 0.50	(Usually $3.5 per million Btu)
Water:	all	$ 0.00000170	
	all		
	all		
	all		
Gas Line Extension	0	$ 1.60	
Fan Replacement	12	$ 0.16	Other **One-Time** Costs
Economizer Install	8	$ 0.0125	(replacements, disposal, etc.)
Resale value:	35	$ 3.70	End of Life Expectancy
Salvage Value:	35	$ 0.03	End of Life Expectancy
Total Cost of Lifetime (Millions):		**$ 474.05**	



CASH FLOWS (IN MILLIONS) FOR 100% Electric

CATEGORY	YEAR # IN LIFETIME	COST	Notes
Initial investment:	0	$ 10.30	
Total Electricity:	all	$ 2.00	(Usually $0.08 per kW/h)
OM & R:	all	$ 0.70	
Water	all	$ 0.0000017	
	all		
	all		
	all		
Fan Replacement	12	$ 1.20	Other **One-Time** Costs
Economizer Install	4	$ 0.10	(replacements, disposal, etc.)
Resale value:	35	$ 0.35	End of Life Expectancy
Salve Value:	35	$ 0.03	End of Life Expectancy
Total Cost of Lifetime (Millions):		**$ 455.93**	



User entries are coded for processing throughout the workbook.

PILOT LCCA ANALYSES:

Completed

- TA-15 Office Trailers
- TA-16 Fire Station Solar PV
- CINT Smart Lab:
  - HVAC
  - Lighting (Troy)
  - Total Renovation

Future

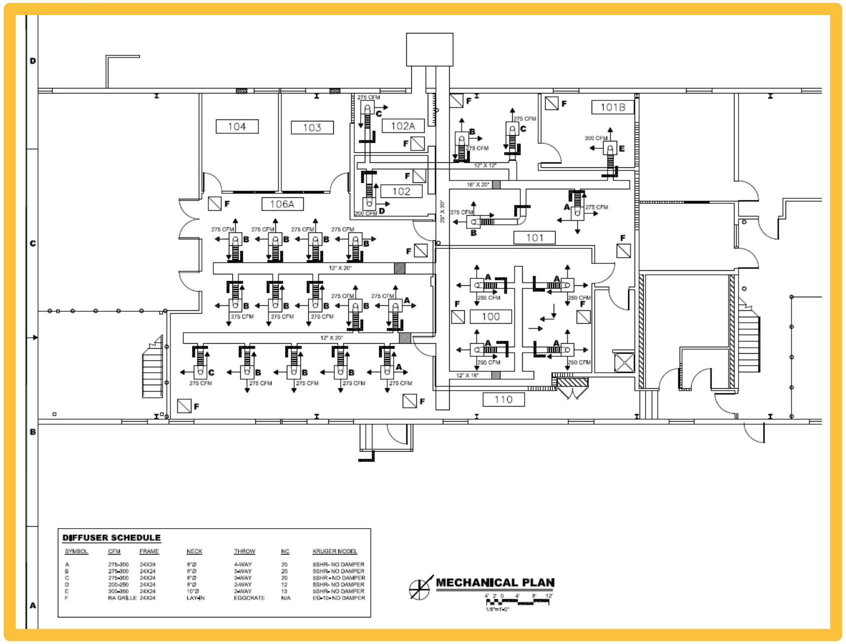
- SM-30 Proposal

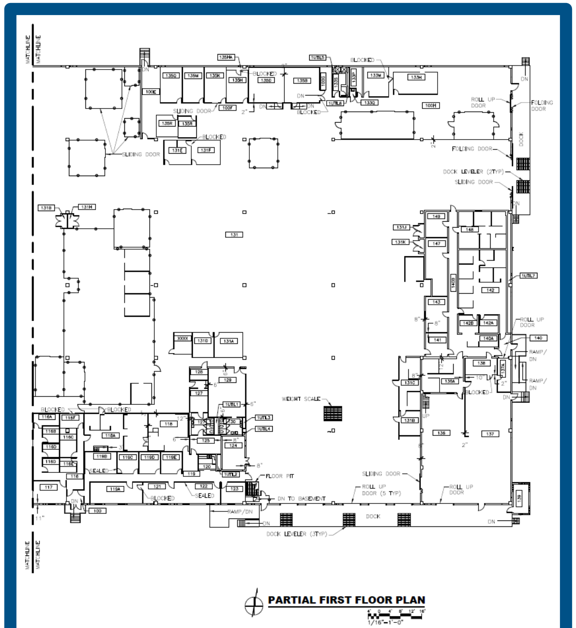
Life-cycle cost is required at LANL to analyze federal structural and energy requirements.

OTHER HVAC PROJECTS:

TA-03-0030:

- Heat load calculations
- LCCA
- Design decisions
- Working with other intern from UI





Office space renovation at LANL is in high demand.

Questions?

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APPENDIX B: LIFE-CYCLE COST ANALYSIS (LCCA)

B.1 INITIAL LCCA WORKBOOK EXAMPLE

Instructions:

This worksheet provides the LCCA comparison between a structure using mixed gas and electric energy and a structure using only electric energy. The lifetime evalued is set at a maximum of 35 years. This worksheet is formatted to be printer-friendly, do not change format.

User must fill in each applicable yellow field input area. Notes are provided for clarity when inputting values. White areas are coded to provide Life-Cycle Cost Analysis (LCCA), do not interfere with these calculations.

The following result can be concluded from this worksheet: General project identificaiton information, cash flow comparisons (visual and numerical), savings-to-investment ratio, and discount payback period.

Terminology Clarifications:

"Year in lifetime" refers to the year at which the cost takes place.

For costs not listed that occur annually, add to highlighted space in "General & Cash Flow" tab where "all" is listed. For costs not listed that occur once, add to highlighted space in "General & Cash Flow" tab where the year must be specified. Specify the year at which the cost takes place in the provided space.

"One-Time Other Costs" refers to investment and operational costs that do not occur annually. For these values, the user will also list the "year in lifetime" in the corresponding input cell. Examples of these costs include replacements such as roofing, mechanical equiptment, etc.

"Lower-First-Cost Option" refers to the cost in a category belonging to the option with the lowest initial investment. *"Higher-First-Cost Option"* refers to the cost in a category belonging to the option with the highest initial investment.

Citations:

Life-Cycle Costing Manual for the Federal Energy Management Program, NIST Handbook 135, 1995 Edition: https://www.nist.gov/publications/life-cycle-costing-manual-federal-energy-management-program-nist-handbook-135-1995

Energy Price Indices and Discount Factors LCCA 2019, Annual Supplement to Handbook 135 : https://www.nist.gov/publications/energy-price-indices-and-discount-factors-life-cycle-cost-analysis-150-2019-annual

Utilities & Infrastructure Facility Operations, Los Alamos National Laboratory. *Author: Matney Juntunen*

Information Needed to Complete this Worksheet:

Gas/Electric Costs: (in Millions)

CATEGORY	YEAR # IN LIFETIME	COST PER YEAR	Notes
Initial investment:	0	$ 110.00	
Total Electricity:	all	$ 13.00	(Usually $0.08 per kW/h)
OM & R:	all	$ 8.00	
Total Natural Gas:	all	$ 0.50	(Usually $3.5 per million Btu)
Water:	all	$ -	
Gas Line Extension:	0	$ -	
Resale value:		$ 3.70	End of Life Expectancy
Salvage Value:			End of Life Expectancy

Gas Line Extension Calculations:

		Notes:
Linear measurement of extension (in feet):		For lines up to 10 inch diameter
Cost per linear foot:	$ 400.00	Includes cost of construction, quoted 5/28/19
Total Cost of Line Extension:		$ -

Annual Water Cost Calculations:

		Notes:
Number of Office Workers:		
Amount of Water Per Person (in kilo-gallons):	0.025	Quoted 5/28/19
Amount of Processes Water Needed (in kilo-gallons):		
Cost of Water (per kgal)	$ 0.00000340	Cost in millions, quoted 5/28/19 at $3.40 per kgal
Total Annual Cost of Water:	$ -	

100% Electric Costs: (in Millions)

CATEGORY	YEAR # IN LIFETIME	COST	Notes
Initial investment:	0	$ 103.00	
Total Electricity:	all	$ 20.00	(Usually $0.08 per kW/h)
OM & R:	all	$ 7.00	
Water:	all	$ -	
Resale value:		$ 3.50	End of Life Expectancy
Salvage Value:			End of Life Expectancy

Annual Water Cost Calculations:		Notes:
Number of Office Workers:		
Amount of Water Per Person (in kilo-gallons):	0.025	Quoted 5/28/19
Amount of Processes Water Needed (in kilo-gallons):		
Cost of Water (per kgal):	$ 0.00000340	Cost in millions, quoted 5/28/19 at $3.40 per kgal
Total Annual Cost of Water:	$ -	

Cost of Gas vs. Electric LCC Analysis Calculator -

See Appendix C in NIST Handbook 135 for Guidance

PROJECT IDENTIFICATION		Notes
Project Name:		
Fiscal year:	1995	
Location:		DoE region
Base Date (BD):		MM/DD/YYYY
Service Date (SD):		MM/DD/YYYY
Design Feature to be Evaluated:		
List Constraints:		Attach page if needed
Energy/Water Conservation Study? (FEMP)	Yes	(yes or no)
OMB A-94?		Office of Management and Budget circular? (yes or no)

BASE CASE AND ALTERNATIVES

Name and describe base case and alternatives to be analyzed:

GENERAL INFORMATION:

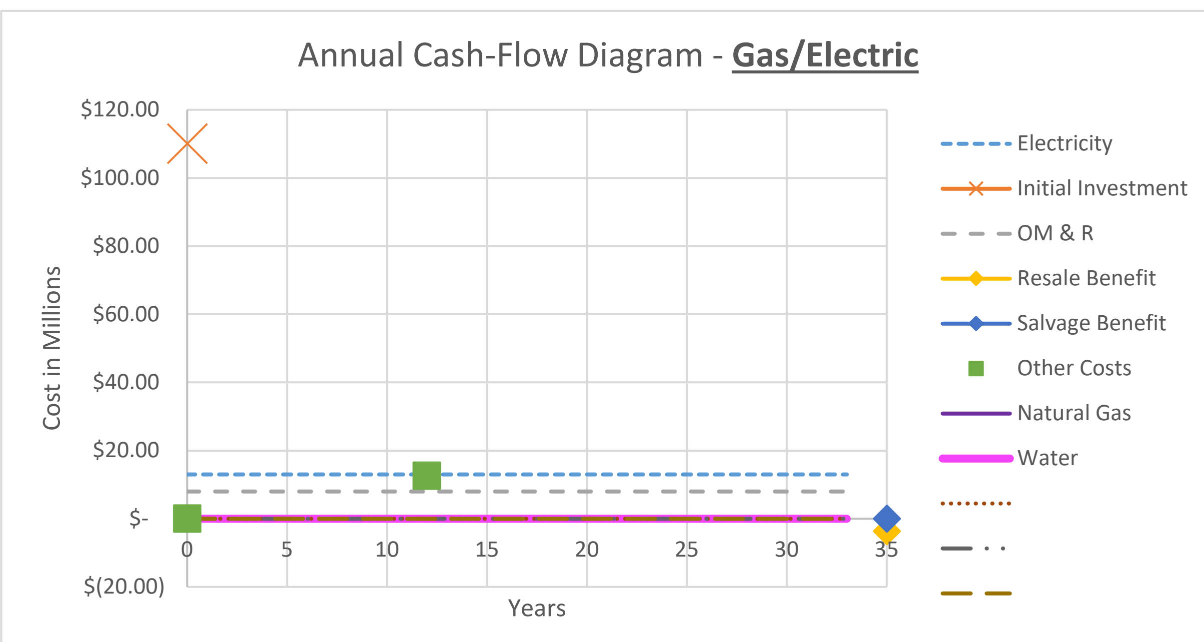
Name of Analyst:		
Phone Number:		
Z-Number:		
Date of Study Completion:		MM/DD/YYYY

KEY DATES		Notes
Years of Life:	35	Quantity (commonly 35 years)
BD:	1/0/1900	
SD:	1/0/1900	
End of Study:	1/0/1900	

Cash Flows Last Updated 6/3/2018

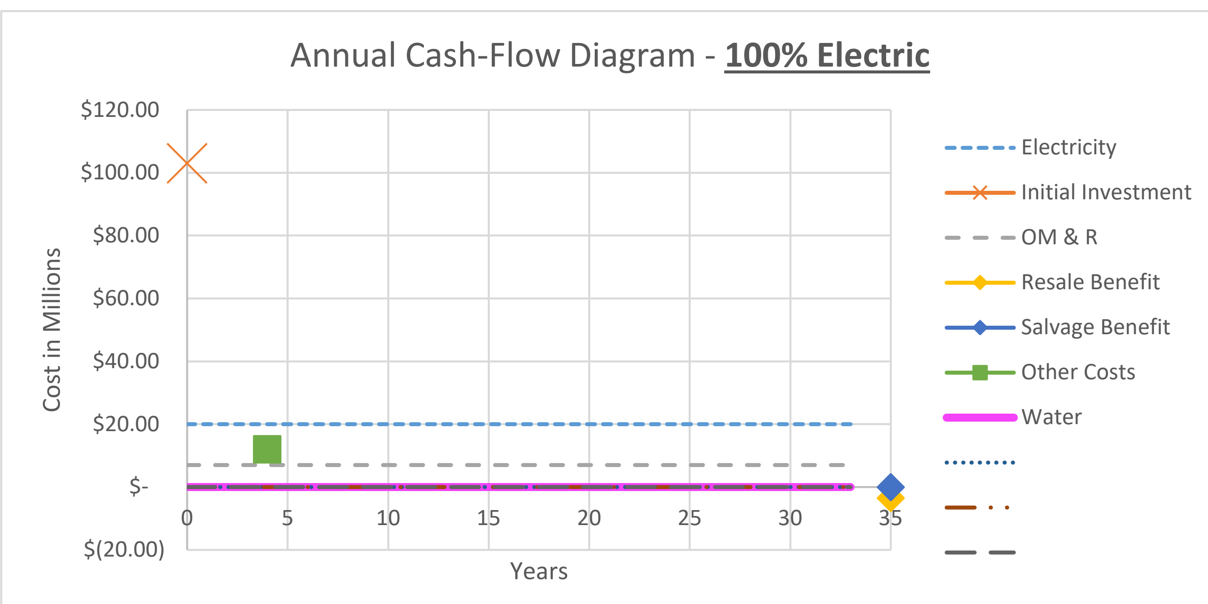
CASH FLOWS (IN MILLIONS) FOR GAS/ELECTRIC

CATEGORY	YEAR # IN LIFETIME	COST PER YEAR		Notes
Initial investment:	0	$	110.00	
Total Electricity:	all	$	13.00	(Usually $0.08 per kW/h)
OM & R:	all	$	8.00	
Total Natural Gas:	all	$	0.50	(Usually $3.5 per million Btu)
Water:	all	$	-	
	all			
	all			
	all			
Gas Line Extension	0	$	-	
Fan Replacement	12	$	12.50	Other **One-Time** Costs (replacements, disposal, etc.)
Resale value:	0	$	3.70	End of Life Expectancy
Salvage Value:	0	$	-	End of Life Expectancy
Total Cost of Lifetime (Millions):		**$**	**4,611.30**	



CASH FLOWS (IN MILLIONS) FOR 100% Electric

CATEGORY	YEAR # IN LIFETIME	COST	Notes
Initial investment:	0	$ 103.00	
Total Electricity:	all	$ 20.00	(Usually $0.08 per kW/h)
OM & R:	all	$ 7.00	
Water	all	$ -	
	all		Other **One-Time** Costs
	all		(replacements, disposal, etc.)
	all		
Fan Replacement	12	$ 12.00	
Resale value:	0	$ 3.50	End of Life Expectancy
Salve Value:	0	$ -	End of Life Expectancy
Total Cost of Lifetime (Millions):		**$ 4,558.50**	



Colum	Column2	Column3	Column4	Column5	Column6	Column63	Column62	Column7	Column16	Column17
Data for Graphs - **Gas/Electric**										
Year	Init. Inv.	Electricity	OMR	Gas	Water	Other1	Other2	Other3	Resale	Salvage
0	$ 110.00	$ 13.00	$ 8.00	$ 0.50	$ -	$ -	$ -	$ -		
3		$ 13.00	$ 8.00	$ 0.50	$ -	$ -	$ -	$ -		
5		$ 13.00	$ 8.00	$ 0.50	$ -	$ -	$ -	$ -		
7		$ 13.00	$ 8.00	$ 0.50	$ -	$ -	$ -	$ -		
9		$ 13.00	$ 8.00	$ 0.50	$ -	$ -	$ -	$ -		
11		$ 13.00	$ 8.00	$ 0.50	$ -	$ -	$ -	$ -		
13		$ 13.00	$ 8.00	$ 0.50	$ -	$ -	$ -	$ -		
15		$ 13.00	$ 8.00	$ 0.50	$ -	$ -	$ -	$ -		
17		$ 13.00	$ 8.00	$ 0.50	$ -	$ -	$ -	$ -		
19		$ 13.00	$ 8.00	$ 0.50	$ -	$ -	$ -	$ -		
21		$ 13.00	$ 8.00	$ 0.50	$ -	$ -	$ -	$ -		
23		$ 13.00	$ 8.00	$ 0.50	$ -	$ -	$ -	$ -		
25		$ 13.00	$ 8.00	$ 0.50	$ -	$ -	$ -	$ -		
27		$ 13.00	$ 8.00	$ 0.50	$ -	$ -	$ -	$ -		
29		$ 13.00	$ 8.00	$ 0.50	$ -	$ -	$ -	$ -		
31		$ 13.00	$ 8.00	$ 0.50	$ -	$ -	$ -	$ -		
33		$ 13.00	$ 8.00	$ 0.50	$ -	$ -	$ -	$ -		
35									$ (3.70)	$ -

Colur	Column2	Column3	Column4	Column4	Column42	Column4	Column43	Column5	Column6
Data for Graphs - 100% Electric									
Year	Init. Inv.	Electricity	OMR	Water	Other1	Other2	Other3	Resale	Salvage
0	$ 103.00	$ 20.00	$ 7.00	$ -	$ -	$ -	$ -		
3		$ 20.00	$ 7.00	$ -	$ -	$ -	$ -		
5		$ 20.00	$ 7.00	$ -	$ -	$ -	$ -		
7		$ 20.00	$ 7.00	$ -	$ -	$ -	$ -		
9		$ 20.00	$ 7.00	$ -	$ -	$ -	$ -		
11		$ 20.00	$ 7.00	$ -	$ -	$ -	$ -		
13		$ 20.00	$ 7.00	$ -	$ -	$ -	$ -		
15		$ 20.00	$ 7.00	$ -	$ -	$ -	$ -		
17		$ 20.00	$ 7.00	$ -	$ -	$ -	$ -		
19		$ 20.00	$ 7.00	$ -	$ -	$ -	$ -		
21		$ 20.00	$ 7.00	$ -	$ -	$ -	$ -		
23		$ 20.00	$ 7.00	$ -	$ -	$ -	$ -		
25		$ 20.00	$ 7.00	$ -	$ -	$ -	$ -		
27		$ 20.00	$ 7.00	$ -	$ -	$ -	$ -		
29		$ 20.00	$ 7.00	$ -	$ -	$ -	$ -		
31		$ 20.00	$ 7.00	$ -	$ -	$ -	$ -		
33		$ 20.00	$ 7.00	$ -	$ -	$ -	$ -		
35								$ (3.50)	$ -

Specify **Gas/Electric** Investment Costs: (in Millions)

CATEGORY	AMOUNT	Notes	DISCOUNT FACTOR	Notes	FACTOR TABLE NO.	PRESENT VALUE
Initial Investment:	$ 110.00		1	(Inflation	-	$ 110.00
Resale:	$ (3.70)		0.554	included in	A-1	$ (2.05)
Salvage:	$ -			NIST		$ -
Fan Replacement	$ 12.50	See previous	0.701	Handbook 135	A-1	$ 8.76
		sheet values		Annual		$ -
		and parts		Suppliment		$ -
				discount		$ -
				factors)		$ -
						$ -

Total Investment-Related Costs: $ 116.71

Specify **Gas/Electric** Operation-Related Costs: (in Millions)

CATEGORY	AMOUNT	Notes	DISCOUNT FACTOR	Notes	FACTOR TABLE NO.	PRESENT VALUE
Total Electricity:	$ 13.00		15.13	(Inflation	Ba-3	$ 196.69
OM & R:	$ 8.00		14.88	included in	A-2	$ 119.04
Total Natural Gas:	$ 0.50			NIST		$ -
Water:	$ -	See previous		Handbook 135		$ -
		sheet values		Annual		$ -
		and parts		Suppliment		$ -
				discount		$ -
				factors)		$ -
						$ -

Total Operation-Related Costs: $ 315.73

Total Gas/Electric Present Value Life Cycle Costs: $ 432.44

Specify **100% Electric** Investment Costs: (in Millions)

CATEGORY	AMOUNT	Notes	DISCOUNT FACTOR	Notes	FACTOR TABLE NO.	PRESENT VALUE
Initial Investment:	$ 103.00		1	(Inflation	-	$ 103.00
Resale:	$ (3.50)		0.554	included in	A-1	$ (1.94)
Salvage:	$ -			NIST		$ -
Fan Replacement	$ 12.00	See previous	0.701	Handbook 135	A-1	$ 8.41
		sheet values		Annual		$ -
		and parts		Suppliment		$ -
				discount		$ -
				factors)		$ -
						$ -
			Total Investment-Related Costs:			$ 109.47

Specify **100% Electric** Operation-Related Costs: (in Millions)

CATEGORY	AMOUNT	Notes	DISCOUNT FACTOR	Notes	FACTOR TABLE NO.	PRESENT VALUE
Total Electricity:	$ 20.00		15.13	(Inflation	Ba-3	$ 302.60
OM & R:	$ 7.00		14.88	included in	A-2	$ 104.16
Water	$ -			NIST		$ -
		See previous		Handbook 135		$ -
		sheet values		Annual		$ -
		and parts		Suppliment		$ -
				discount		$ -
				factors)		$ -
			Total Operation-Related Costs:			$ 406.76

Total 100% Electric Present Value Life Cycle Costs: $ 516.23

Calculate Savings-to-Investment Ratio:

Operational-Related Costs:	Lower-First-Cost Option	Higher-First-Cost Option	Savings
Total Energy:	$ 302.60	$ 196.69	$ 105.91
OM & R:	$ 104.16	$ 119.04	$ (14.88)
Water:	$ -	$ -	$ -
Sum of Other Costs:	$ -	$ -	$ -
Total Op. Savings (in Millions):			**$ 91.03**

Investment-Related Costs:	Higher-First-Cost Option	Lower-First-Cost Option	Savings
Initial Investment:	$ 110.00	$ 103.00	$ 7.00
Resale+Salvage:	$ (2.05)	$ (1.94)	$ (0.11)
Sum of Other Costs:	$ 8.76	$ 8.41	$ 0.35
Total Additional Investment (in Millions):			**$ 7.24**

Savings-to-Investments Ratio (SIR): 12.57373

Discount Payback Period Calculation:

Table DPP1: CALCULATION OF DIFFERENTIAL AMOUNTS (in Millions)

Category:	Lower-First-Cost Option	Higher-First-Cost Option	Differential Amount	Notes
Initial Investment:	$ 103.00	$ 110.00	$ (7.00)	In dollars at time of Base Date (BD).
Total Energy:	$ 20.00	$ 13.00	$ 7.00	
OM & R:	$ 7.00	$ 8.00	$ (1.00)	
Water:	$ -	$ -	$ -	
Sum of Other Annual Costs:	$ -	$ 0.50	$ (0.50)	Gas/Elec Cost includes natural gas.
	$ 12.00	12.5	$ (0.50)	User fills in **one-time cost** of same type. Place name in category column, and cost in appropriate column.
			$ -	
			$ -	
			$ -	
			$ -	

Note: The differential amount above will be used in Table DPP3 below

Table DPP2: CALCULATIONS (IN MILLIONS)

Column1	Column2	Column3	Column4	Column5	Column6	Column7	Column8
Service Year	Annual Energy Savings	Change in OM&R and other	Change in Capital Replaceme-nts	Present Value (PV) Savings	Cumulative PV Savings	Change in PV Initial Investment	PV net savings
1995	$ 7.070	$ (1.000)	$ -	$ 5.894	$ 5.894	$ (7.000)	$ (1.106)
1996	$ 7.070	$ (1.000)	$ -	$ 5.724	$ 11.618	$ (7.000)	$ 4.618
1997	$ 7.000	$ (1.000)	$ -	$ 5.490	$ 17.108	$ (7.000)	$ 10.108
1998	$ 7.000	$ (1.000)	$ -	$ 5.328	$ 22.436	$ (7.000)	$ 15.436
1999	$ 7.070	$ (1.000)	$ -	$ 5.238	$ 27.674	$ (7.000)	$ 20.674
2000	$ 7.140	$ (1.000)	$ -	$ 5.139	$ 32.814	$ (7.000)	$ 25.814
2001	$ 7.210	$ (1.000)	$ -	$ 5.049	$ 37.862	$ (7.000)	$ 30.862
2002	$ 7.210	$ (1.000)	$ -	$ 4.900	$ 42.762	$ (7.000)	$ 35.762
2003	$ 7.210	$ (1.000)	$ -	$ 4.757	$ 47.519	$ (7.000)	$ 40.519
2004	$ 7.210	$ (1.000)	$ -	$ 4.620	$ 52.139	$ (7.000)	$ 45.139
2005	$ 7.140	$ (1.000)	$ -	$ 4.433	$ 56.572	$ (7.000)	$ 49.572
2006	$ 7.070	$ (1.000)	$ (0.500)	$ 3.905	$ 60.477	$ (7.000)	$ 53.477
2007	$ -	$ (1.000)	$ -	$ -	$ 60.477	$ (7.000)	$ 53.477
2008	$ -	$ (1.000)	$ -	$ -	$ 60.477	$ (7.000)	$ 53.477
2009	$ -	$ (1.000)	$ -	$ -	$ 60.477	$ (7.000)	$ 53.477
2010	$ -	$ (1.000)	$ -	$ -	$ 60.477	$ (7.000)	$ 53.477
2011	$ -	$ (1.000)	$ -	$ -	$ 60.477	$ (7.000)	$ 53.477
2012	$ -	$ (1.000)	$ -	$ -	$ 60.477	$ (7.000)	$ 53.477
2013	$ -	$ (1.000)	$ -	$ -	$ 60.477	$ (7.000)	$ 53.477
2014	$ -	$ (1.000)	$ -	$ -	$ 60.477	$ (7.000)	$ 53.477
2015	$ -	$ (1.000)	$ -	$ -	$ 60.477	$ (7.000)	$ 53.477
2016	$ -	$ (1.000)	$ -	$ -	$ 60.477	$ (7.000)	$ 53.477
2017	$ -	$ (1.000)	$ -	$ -	$ 60.477	$ (7.000)	$ 53.477
2018	$ -	$ (1.000)	$ -	$ -	$ 60.477	$ (7.000)	$ 53.477
2019	$ -	$ (1.000)	$ -	$ -	$ 60.477	$ (7.000)	$ 53.477
2020	$ -	$ (1.000)	$ -	$ -	$ 60.477	$ (7.000)	$ 53.477
2021	$ -	$ (1.000)	$ -	$ -	$ 60.477	$ (7.000)	$ 53.477
2022	$ -	$ (1.000)	$ -	$ -	$ 60.477	$ (7.000)	$ 53.477
2023	$ -	$ (1.000)	$ -	$ -	$ 60.477	$ (7.000)	$ 53.477
2024	$ -	$ (1.000)	$ -	$ -	$ 60.477	$ (7.000)	$ 53.477
2025	$ -	$ (1.000)	$ -	$ -	$ 60.477	$ (7.000)	$ 53.477
2026	$ -	$ (1.000)	$ -	$ -	$ 60.477	$ (7.000)	$ 53.477
2027	$ -	$ (1.000)	$ -	$ -	$ 60.477	$ (7.000)	$ 53.477
2028	$ -	$ (1.000)	$ -	$ -	$ 60.477	$ (7.000)	$ 53.477
End of Lifetime							

Notes: Use tables **Ca-4** through **Ca-5** of the *Energy Price Indices and Discount Factors LCCA 2019, Annual Supplement to Handbook 135* (page 39) to calculate annual energy savings.
https://www.nist.gov/publications/energy-price-indices-and-discount-factors-life-cycle-cost-analysis-
Use tables ____________________ of the Energy Price Indices and Discount Factors LCCA 2019, Annual

Supplement to Handbook 135 (page ____) to calculate PV savings.

Table DPP3: CALCULATE COMPONENTS OF DPP CALCULATION TABLE ABOVE

Year	Energy Savings	Energy Price Index (1995)	Other One-Time Costs	<-- Notes	SPV Factor Index (1995)
2019	$ 7.00	1.01		User enters differential amount (Table DPP1, Column E) into correct year.	0.971
2020	$ 7.00	1.01			0.943
2021	$ 7.00	1			0.915
2022	$ 7.00	1			0.888
2023	$ 7.00	1.01			0.863
2024	$ 7.00	1.02			0.837
2025	$ 7.00	1.03			0.813
2026	$ 7.00	1.03		A negative value is shown inside parentheses, and must be entered as negative in the input section.	0.789
2027	$ 7.00	1.03			0.766
2028	$ 7.00	1.03			0.744
2029	$ 7.00	1.02			0.722
2030	$ 7.00	1.01	$ (0.50)		0.701
2031	$ 7.00				
2032	$ 7.00				
2033	$ 7.00				
2034	$ 7.00				
2035	$ 7.00				
2036	$ 7.00				
2037	$ 7.00				
2038	$ 7.00				
2039	$ 7.00				
2040	$ 7.00				
2041	$ 7.00				
2042	$ 7.00				
2043	$ 7.00				
2044	$ 7.00				
2045	$ 7.00				
2046	$ 7.00				
2047	$ 7.00				
2048	$ 7.00				
2049	$ 7.00				
2050	$ 7.00				
2051	$ 7.00				
2052	$ 7.00				
2053	$ 7.00				

Discount Payback Period Result:

First Positive Savings:	$	4.618
PAYBACK PERIOD:		2
FISCAL YEAR OF DISCOUNT PAYBACK:		1997

SUMMARY OF LIFE-CYCLE COST ANALYSIS

PROJECT IDENTIFICATION

Project Name:	0
Fiscal year:	1995
Location:	0
Base Date (BD):	1/0/1900
Service Date (SD):	1/0/1900
Design feature to be Evaluated:	0
List Constraints:	0
Energy/Water Conservation Study? (FEMP)	Yes
OMB A-94?	0

BASE CASE AND ALTERNATIVES

Name and describe base case and alternatives to be analyzed:

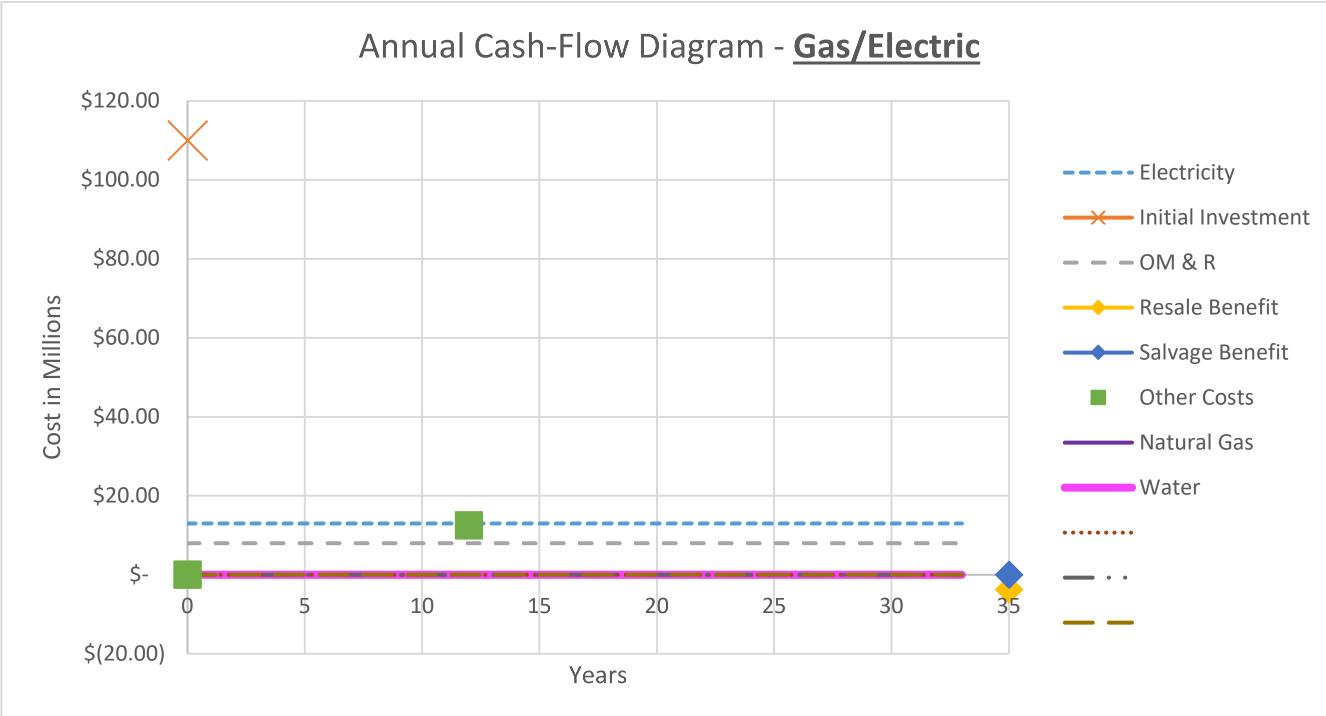
0

GENERAL INFORMATION:

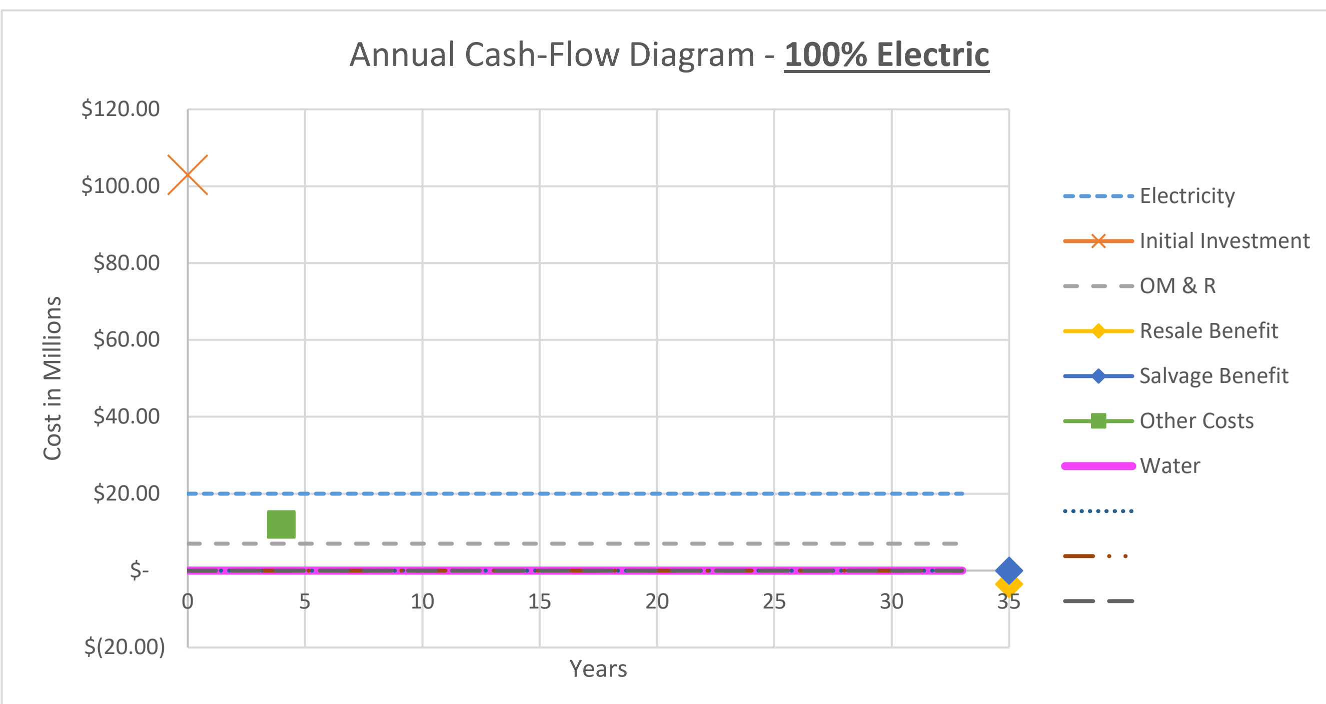
Name of Analyst:	0
Phone Number:	0
Z-Number:	0
Date of Study Completion:	1/0/1900

KEY DATES

Years of Life:	35
BD:	1/0/1900
SD:	1/0/1900
End of Study:	1/0/1900



Total Cost of Gas/Electric Lifetime: **$ 4,611.30**



Total Cost of 100% Electric Lifetime: **$ 4,558.50**

SAVINGS-TO-INVESTMENT RATIO:

Total Gas/Electric Present Value Life Cycle Costs:	$ 432.44
Total 100% Electric Present Value Life Cycle Costs:	$ 516.23
Savings-to-Investments Ratio (SIR):	12.5737

DISCOUNT PAYBACK PERIOD:

Discount Payback Period:	2
Fiscal year of Discount Payback:	1997

B.2 TEST STUDY: CINT SMART LAB LIGHTING

Instructions:

This worksheet provides the LCCA comparison between a structure using mixed gas and electric energy and a structure using only electric energy. The lifetime evalued is set at a maximum of 35 years. This worksheet is formatted to be printer-friendly, do not change format. Only DOE projects may use this calculator.

User must fill in each applicable yellow field input area. Notes are provided for clarity when inputting values. White areas are coded to provide Life-Cycle Cost Analysis (LCCA), do not interfere with these calculations.

The following result can be concluded from this worksheet: General project identificaiton information, cash flow comparisons (visual and numerical), savings-to-investment ratio, and discount payback period.

Terminology Clarifications:

"Year in lifetime" refers to the year at which the cost takes place.
For costs not listed that occur annually, add to highlighted space in "General & Cash Flow" tab where "all" is listed. For costs not listed that occur once, add to highlighted space in "General & Cash Flow" tab where the year must be specified. Specify the year at which the cost takes place in the provided space.

"One-Time Other Costs" refers to investment and operational costs that do not occur annually. For these values, the user will also list the "year in lifetime" in the corresponding input cell. Examples of these costs include replacements such as roofing, mechanical equiptment, etc.

"Lower-First-Cost Option" refers to the cost in a category belonging to the option with the lowest initial investment. *"Higher-First-Cost Option"* refers to the cost in a category belonging to the option with the highest initial investment.

Citations:

Life-Cycle Costing Manual for the Federal Energy Management Program, NIST Handbook 135, 1995 Edition:
https://www.nist.gov/publications/life-cycle-costing-manual-federal-energy-management-program-nist-handbook-135-1995

Energy Price Indices and Discount Factors LCCA 2019, Annual Supplement to Handbook 135 :
https://www.nist.gov/publications/energy-price-indices-and-discount-factors-life-cycle-cost-analysis-150-2019-annual

Utilities & Infrastructure Facility Operations, Los Alamos National Laboratory.
Author: Matney Juntunen

Information Needed to Complete this Workbook:

Option A Costs: (in Thousands)

CATEGORY	YEAR # IN LIFETIME	COST PER YEAR	Notes
Initial investment:	1	$ -	
Total Electricity:	Annual	$ 17.79	(Usually $0.08 per kW/h)
OM & R:	Annual	$ 40.00	
Total Natural Gas:	Annual	$ -	(Usually $3.5 per million Btu)
Water:	Annual	$ -	
Gas Line Extension:	1	$ -	
Resale value:	0	$ -	End of Life Expectancy
Salvage Value:	0	$ -	End of Life Expectancy

Gas Line Extension Calculations:

		Notes:
Linear measurement of extension (in feet):	0	For lines up to 10 inch diameter
Cost per linear foot:	$ 0.04	Includes cost of construction, quoted 5/28/19
Total Cost of Line Extension:		$ -

Annual Water Cost Calculations:

		Notes:
Number of Office Workers:	0	
Amount of Water Per Person (in kilo-gallons):	0.025	Quoted 5/28/19
Amount of Processes Water Needed (in kilo-gallons):	0	
Cost of Water (per kgal)	$ 0.00340000	Cost in thousands, quoted 5/28/19 at $3.40 per kgal
Total Annual Cost of Water:	$ -	

Information for Workbook Continued:

Option B Costs: (in Thousands)

CATEGORY	YEAR # IN LIFETIME	COST	Notes
Initial investment:	1	$ 144.93	
Total Electricity:	Annual	$ 12.52	(Usually $0.08 per kW/h)
OM & R:	Annual	$ 4.00	
Water:	Annual	$ -	
Resale value:	0	$ -	End of Life Expectancy
Salvage Value:	0	$ -	End of Life Expectancy

Annual Water Cost Calculations:

		Notes:
Number of Office Workers:	0	
Amount of Water Per Person (in kilo-gallons):	0.025	Quoted 5/28/19
Amount of Processes Water Needed (in kilo-gallons):	0	
Cost of Water (per kgal):	$ 0.00340000	Cost in thousands, quoted 5/28/19 at $3.40 per kgal
Total Annual Cost of Water:	$ -	

Cost of Gas vs. Electric LCC Analysis Calculator - See Appendix C in NIST Handbook 135 for Guidance

PROJECT IDENTIFICATION		Notes
Project ID No:	??????	
Fiscal year:	2019	
Location:	TA 03-1420	DoE Region, LANL Building
Base Date (BD):	7/2/2019	MM/DD/YYYY (Start of study)
Service Date (SD):	????????	MM/DD/YYYY (Occupancy)
Design Feature to be Evaluated:	T8 lamps to LED lamps.	
List Constraints:	None.	Attach page if needed
Energy/Water Conservation Study? (FEMP)	Yes	
OMB A-94?	No	Office of Management and Budget circular not at LANL

BASE CASE AND ALTERNATIVES

Name and describe base case (lower initial investment) and alternatives to be analyzed:

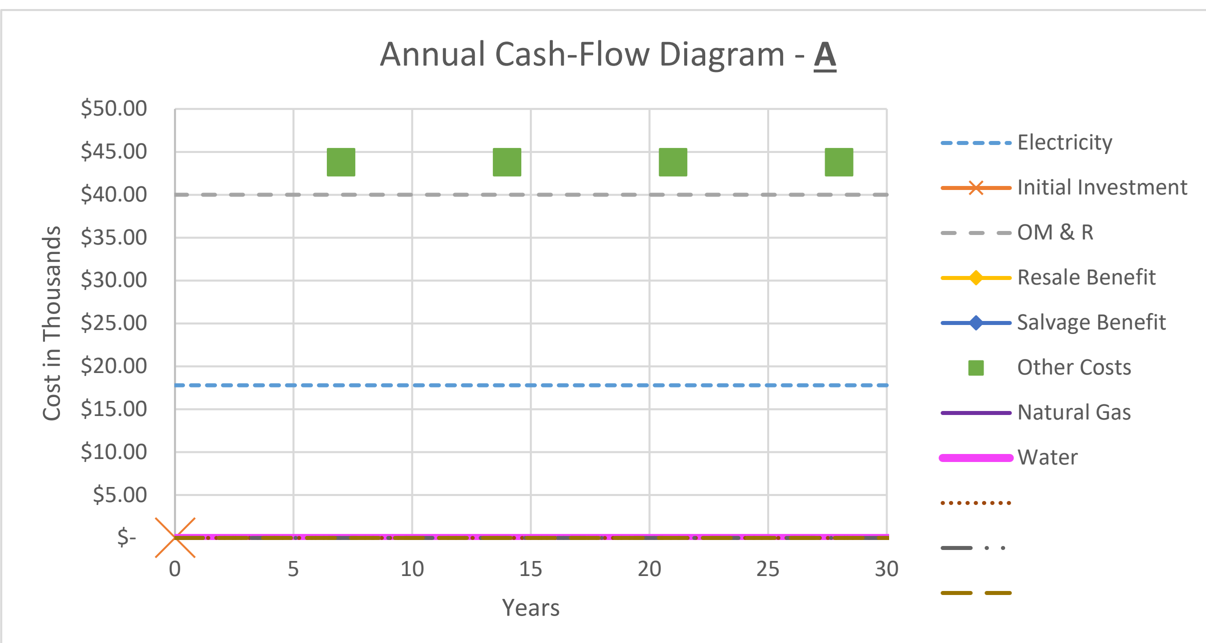
GENERAL INFORMATION:		
Name of Analyst:		
Phone Number:		
Z-Number:		
Date of Study Completion:	??/??/????	MM/DD/YYYY

KEY DATES		Notes
Years of Life:	30	Quantity (commonly 25-30 years)
BD:	7/2/2019	
SD:	????????	
End of Study:	??/??/????	

Cash Flows Last Updated 6/3/2018

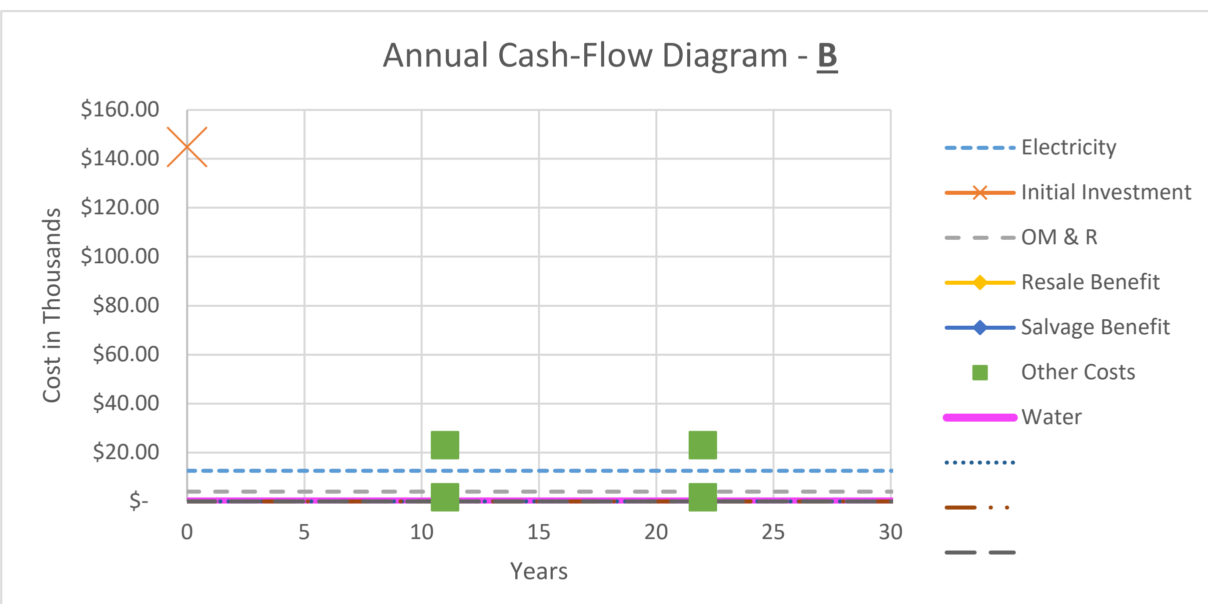
CASH FLOWS (IN THOUSANDS) FOR OPTION A

CATEGORY	YEAR # IN LIFETIME	COST PER YEAR		Notes
Initial investment:	1	$	-	
Total Electricity:	Annual	$	17.79	(Usually $0.08 per kW/h)
OM & R:	Annual	$	40.00	
Total Natural Gas:	Annual	$	-	(Usually $3.5 per million Btu)
Water:	Annual	$	-	
	Annual			
	Annual			
	Annual			
Waste and Replace	7	$	43.77	Other **One-Time** Costs
Waste and Replace	14	$	43.77	(replacements, disposal, etc.)
Waste and Replace	21	$	43.77	
Waste and Replace	28	$	43.77	
Resale value:	0	$	-	End of Life Expectancy
Salvage Value:	0	$	-	End of Life Expectancy



CASH FLOWS (IN THOUSANDS) FOR OPTION B

CATEGORY	YEAR # IN LIFETIME	COST		Notes
Initial investment:	1	$	144.93	
Total Electricity:	Annual	$	12.52	(Usually $0.08 per kW/h)
OM & R:	Annual	$	4.00	
Water	Annual	$	-	
	Annual			
	Annual			
	Annual			
Recycle	11	$	1.67	Other **One-Time** Costs
Recycle	22	$	1.67	(replacements, disposal, etc.)
Replace	11	$	23.00	
Replace	22	$	23.00	
Resale value:	0	$	-	End of Life Expectancy
Salve Value:	0	$	-	End of Life Expectancy



Colum	Column2	Column3	Column4	Column5	Column6	Column63	Column62	Column7	Column16	Column17
Data for Graphs - A										
Year	Init. Inv.	Electricity	OMR	Gas	Water	Other1	Other2	Other3	Resale	Salvage
0	$ -	$ 17.79	$ 40.00	$ -	$ -	$ -	$ -	$ -		
3		$ 17.79	$ 40.00	$ -	$ -	$ -	$ -	$ -		
5		$ 17.79	$ 40.00	$ -	$ -	$ -	$ -	$ -		
7		$ 17.79	$ 40.00	$ -	$ -	$ -	$ -	$ -		
9		$ 17.79	$ 40.00	$ -	$ -	$ -	$ -	$ -		
11		$ 17.79	$ 40.00	$ -	$ -	$ -	$ -	$ -		
13		$ 17.79	$ 40.00	$ -	$ -	$ -	$ -	$ -		
15		$ 17.79	$ 40.00	$ -	$ -	$ -	$ -	$ -		
17		$ 17.79	$ 40.00	$ -	$ -	$ -	$ -	$ -		
19		$ 17.79	$ 40.00	$ -	$ -	$ -	$ -	$ -		
21		$ 17.79	$ 40.00	$ -	$ -	$ -	$ -	$ -		
23		$ 17.79	$ 40.00	$ -	$ -	$ -	$ -	$ -		
25		$ 17.79	$ 40.00	$ -	$ -	$ -	$ -	$ -		
27		$ 17.79	$ 40.00	$ -	$ -	$ -	$ -	$ -		
29		$ 17.79	$ 40.00	$ -	$ -	$ -	$ -	$ -		
31		$ 17.79	$ 40.00	$ -	$ -	$ -	$ -	$ -		
33		$ 17.79	$ 40.00	$ -	$ -	$ -	$ -	$ -		
35									$ -	$ -

Colur	Column2	Column3	Column4	Column5	Column6	Column7	Column8	Column9	Column10
Data for Graphs - B									
Year	Init. Inv.	Electricity	OMR	Water	Other1	Other2	Other3	Resale	Salvage
0	$ 144.93	$ 12.52	$ 4.00	$ -	$ -	$ -	$ -		
3		$ 12.52	$ 4.00	$ -	$ -	$ -	$ -		
5		$ 12.52	$ 4.00	$ -	$ -	$ -	$ -		
7		$ 12.52	$ 4.00	$ -	$ -	$ -	$ -		
9		$ 12.52	$ 4.00	$ -	$ -	$ -	$ -		
11		$ 12.52	$ 4.00	$ -	$ -	$ -	$ -		
13		$ 12.52	$ 4.00	$ -	$ -	$ -	$ -		
15		$ 12.52	$ 4.00	$ -	$ -	$ -	$ -		
17		$ 12.52	$ 4.00	$ -	$ -	$ -	$ -		
19		$ 12.52	$ 4.00	$ -	$ -	$ -	$ -		
21		$ 12.52	$ 4.00	$ -	$ -	$ -	$ -		
23		$ 12.52	$ 4.00	$ -	$ -	$ -	$ -		
25		$ 12.52	$ 4.00	$ -	$ -	$ -	$ -		
27		$ 12.52	$ 4.00	$ -	$ -	$ -	$ -		
29		$ 12.52	$ 4.00	$ -	$ -	$ -	$ -		
31		$ 12.52	$ 4.00	$ -	$ -	$ -	$ -		
33		$ 12.52	$ 4.00	$ -	$ -	$ -	$ -		
35								$ -	$ -

Specify Option A: (in Thousands)

CATEGORY	AMOUNT	Notes	Year in Lifetime	DISCOUNT FACTOR (**SPV**)	Notes	PRESENT VALUE
Initial Investment:	$ -		1	0.971	(Rates included in NIST Handbook 135 Annual Suppliment discount factors. **Must discount to ending year of occurance**).	$ -
Resale:	$ -		30	0.412		$ -
Salvage:	$ -		30	0.412		$ -
		See previous sheet values and parts				$ -
						$ -
						$ -
						$ -
						$ -
						$ -

Total Investment-Related Costs: $ -

Specify Option A Operation-Related Costs: (in Thousands)

CATEGORY	AMOUNT	Notes	Year in lifetime/end year of occurances	DISCOUNT FACTOR (**UPV or SPV**)	Notes	PRESENT VALUE
Total Electricity:	$ 17.79		30	19.6	(Rates included in NIST Handbook 135 Annual Suppliment discount factors. **Must discount to ending year of occurance**).	$ 348.74
OM & R:	$ 40.00		30	19.6		$ 784.00
Total Natural Gas:	$ -					$ -
Water:	$ -					$ -
Waste and Replace	$ 43.77	See previous sheet values and parts	7	0.813		$ 35.58
Waste and Replace	$ 43.77		14	0.661		$ 28.93
Waste and Replace	$ 43.77		21	0.538		$ 23.55
Waste and Replace	$ 43.77		28	0.437		$ 19.13
						$ -

Total Operation-Related Costs: $ 1,239.93

Total Option A Present Value Life Cycle Costs: $ 1,239.93

Note: See Tables from the *Energy Price Indices and Discount Factors LCCA 2019, Annual Supplement to Handbook 135* to find discount factors.

UPV is for uniform/annual costs, while SPV is for single expense/one-time costs.

Specify Option B Costs: (in Thousands)

CATEGORY	AMOUNT	Notes	Year in Lifetime	DISCOUNT FACTOR (**SPV**)	FACTOR TABLE NO.	PRESENT VALUE
Initial Investment:	$ 144.93		1	0.971	(Rates included in NIST Handbook 135 Annual Suppliment discount factors. **Must discount to ending year of occurance**).	$ 140.73
Resale:	$ -		30			$ -
Salvage:	$ -		30			$ -
		See previous sheet values and parts				$ -
						$ -
						$ -
						$ -
						$ -
						$ -

Total Investment-Related Costs: $ 140.73

Specify Option B Operation-Related Costs: (in Thousands)

CATEGORY	AMOUNT	Notes	Year in lifetime/end year of occurances	DISCOUNT FACTOR (**SPV or UPV**)	FACTOR TABLE NO.	PRESENT VALUE
Total Electricity:	$ 12.52		30	19.6	(Rates included in NIST Handbook 135 Annual Suppliment discount factors. **Must discount to ending year of occurance**).	$ 245.36
OM & R:	$ 4.00		30	19.6		$ 78.40
Water	$ -		30	19.6		$ -
Recycle and Replace	$ 24.67	See previous sheet values and parts	11	0.722		$ 17.81
Recycle and Replace	$ 24.67		22	0.522		$ 12.88
						$ -
						$ -
						$ -

Total Operation-Related Costs: $ 354.45

Total Option B Present Value Life Cycle Costs: $ 495.18

Note: See Tables from the *Energy Price Indices and Discount Factors LCCA 2019, Annual Supplement to Handbook 135* to find discount factors.

UPV is for uniform/annual costs, while SPV is for single expense/one-time costs.

Calculate Savings-to-Investment Ratio:

Operational-Related Costs:	Lower-First-Cost Option	Higher-First-Cost Option	Savings
Total Energy:	$ 348.74	$ 245.36	$ 103.38
OM & R:	$ 784.00	$ 78.40	$ 705.60
Water:	$ -	$ -	$ -
Sum of Other Costs:	$ 107.19	$ 30.69	$ 76.50
		Total Op. Savings (in Thousands):	**$ 885.48**

Investment-Related Costs:	Higher-First-Cost Option	Lower-First-Cost Option	Savings
Initial Investment:	$ 140.73	$ -	$ 140.73
Resale+Salvage:	$ -	$ -	$ -
Sum of Other Costs:	$ -	$ -	$ -
		Total Additional Investment (in Thousands):	**$ 140.73**

Savings-to-Investments Ratio (SIR): 6.292112

SIR is cost effective if the ratio is greater than 1. This measure is relative to the base case.

Discount Payback Period Calculation:

Table DPP1: CALCULATION OF DIFFERENTIAL AMOUNTS (IN THOUSANDS)				
Category:	Lower-First-Cost Option	Higher-First-Cost Option	Differential Amount	Notes
Initial Investment:	$ -	$ 144.93	$ (144.93)	In dollars at time of Base Date (BD).
Total Energy:	$ 17.79	$ 12.52	$ 5.27	
OM & R:	$ 40.00	$ 4.00	$ 36.00	
Water:	$ -	$ -	$ -	
Sum of Other Annual Costs:	$ -	$ -	$ -	Gas/Elec Cost includes natural gas.
Dispose/Replace	$ 87.54	$ 24.67	$ 62.87	User fills in **one-time cost** of same type. Place name in category column, and cost in appropriate column.
Dispose/Replace	$ 87.54	$ 24.67	$ 62.87	
			$ -	
			$ -	
			$ -	
Resale/Salvage	$ -	$ -	$ -	
Note: The differential amounts above will be used in **Table DPP3** below				

Table DPP2: DOE CALCULATIONS (IN THOUSANDS)

Column1	Column2	Column3	Column4	Column5	Column6	Column7	Column8
Service Year	Annual Energy Savings	Change in OM&R, Water, and Other	Change in Capital Replacements	Present Value (PV) Savings DOE	Cumulative PV Savings	Change in PV Initial Investment	PV net savings
2019	$ -	$ -	$ -	$ -	$ -	$ -	$ -
2020	$ 9.104	$ 36.000	$ -	$ 45.104	$ 45.104	$ (136.671)	$ (91.567)
2021	$ 8.985	$ 36.000	$ -	$ 44.985	$ 90.089	$ (132.613)	$ (42.524)
2022	$ 9.078	$ 36.000	$ -	$ 45.078	$ 135.167	$ (128.700)	$ 6.467
2023	$ 9.211	$ 36.000	$ -	$ 45.211	$ 180.378	$ (125.076)	$ 55.302
2024	$ 9.304	$ 36.000	$ -	$ 45.304	$ 225.681	$ (121.308)	$ 104.373
2025	$ 9.529	$ 36.000	$ -	$ 45.529	$ 271.211	$ (117.830)	$ 153.381
2026	$ 9.675	$ 36.000	$ -	$ 45.675	$ 316.885	$ (114.351)	$ 202.534
2027	$ 9.715	$ 36.000	$ -	$ 45.715	$ 362.600	$ (111.018)	$ 251.582
2028	$ 9.755	$ 36.000	$ -	$ 45.755	$ 408.354	$ (107.829)	$ 300.525
2029	$ 10.195	$ 36.000	$ -	$ 46.195	$ 454.549	$ (104.641)	$ 349.908
2030	$ 10.407	$ 36.000	$ 45.39	$ 91.798	$ 546.347	$ (101.597)	$ 444.750
2031	$ 10.540	$ 36.000	$ -	$ 46.540	$ 592.887	$ (98.699)	$ 494.188
2032	$ 10.580	$ 36.000	$ -	$ 46.580	$ 639.467	$ (95.800)	$ 543.667
2033	$ 10.673	$ 36.000	$ -	$ 46.673	$ 686.140	$ (93.046)	$ 593.093
2034	$ 10.660	$ 36.000	$ -	$ 46.660	$ 732.800	$ (90.293)	$ 642.507
2035	$ 10.700	$ 36.000	$ -	$ 46.700	$ 779.500	$ (87.684)	$ 691.816
2036	$ 10.793	$ 36.000	$ -	$ 46.793	$ 826.293	$ (85.075)	$ 741.218
2037	$ 10.793	$ 36.000	$ -	$ 46.793	$ 873.085	$ (82.611)	$ 790.474
2038	$ 10.833	$ 36.000	$ -	$ 46.833	$ 919.918	$ (80.292)	$ 839.626
2039	$ 10.780	$ 36.000	$ -	$ 46.780	$ 966.698	$ (77.973)	$ 888.725
2040	$ 10.820	$ 36.000	$ -	$ 46.820	$ 1,013.518	$ (75.655)	$ 937.864
2041	$ 10.820	$ 36.000	$ 32.82	$ 79.637	$ 1,093.156	$ (73.481)	$ 1,019.675
2042	$ 10.807	$ 36.000	$ -	$ 46.807	$ 1,139.963	$ (71.307)	$ 1,068.656
2043	$ 10.847	$ 36.000	$ -	$ 46.847	$ 1,186.810	$ (69.277)	$ 1,117.533
2044	$ 10.835	$ 36.000	$ -	$ 46.835	$ 1,233.645	$ (67.248)	$ 1,166.396
2045	$ 10.875	$ 36.000	$ -	$ 46.875	$ 1,280.519	$ (65.219)	$ 1,215.300
2046	$ 10.915	$ 36.000	$ -	$ 46.915	$ 1,327.434	$ (63.335)	$ 1,264.099
2047	$ 10.955	$ 36.000	$ -	$ 46.955	$ 1,374.388	$ (61.451)	$ 1,312.937
2048	$ 10.995	$ 36.000	$ -	$ 46.995	$ 1,421.383	$ (59.712)	$ 1,361.671
2049	$ 11.022	$ 36.000	$ -	$ 47.022	$ 1,468.405	$ -	$ 1,468.405
End of Lifetime							

Notes: Use tables **Ca-4** through **Ca-5** of the *Energy Price Indices and Discount Factors LCCA 2019, Annual Supplement to Handbook 135* (page 39) to calculate annual energy savings.
https://www.nist.gov/publications/energy-price-indices-and-discount-factors-life-cycle-cost-analysis-150-

Table DPP3: CALCULATE COMPONENTS OF DPP CALCULATION TABLE ABOVE

Year	Electricity Savings	Fuel Index - Commercial Electricity (2019)	Fuel Index - Commercial Natural Gas (2019)	Other One-Time Cost Differentials	<-- Notes	SPV Factor Index **DOE** Discount Rate (2019)	UPV* Factor Index **DOE** Discount Rate (2019)
2019	$ -	0.00	0.00		User enters differential amount (Table DPP1, Column E) into correct year.	0	1.0
2020	$ 5.27	0.96	1.01			0.971	2.0
2021	$ 5.27	0.93	1.02			0.943	3.0
2022	$ 5.27	0.94	1.03			0.915	4.0
2023	$ 5.27	0.95	1.05			0.888	5.0
2024	$ 5.27	0.96	1.06			0.863	6.0
2025	$ 5.27	0.98	1.09			0.837	7.0
2026	$ 5.27	1.00	1.10		A negative value is shown inside parentheses, and must be entered as negative in the input section.	0.813	8.0
2027	$ 5.27	1.00	1.11			0.789	9.0
2028	$ 5.27	1.00	1.12			0.766	10.0
2029	$ 5.27	1.00	1.23			0.744	11.0
2030	$ 5.27	1.01	1.27	$ 62.87		0.722	12.0
2031	$ 5.27	1.02	1.29			0.701	13.0
2032	$ 5.27	1.02	1.30			0.681	14.0
2033	$ 5.27	1.03	1.31			0.661	15.0
2034	$ 5.27	1.02	1.32			0.642	16.0
2035	$ 5.27	1.02	1.33			0.623	17.0
2036	$ 5.27	1.03	1.34			0.605	18.0
2037	$ 5.27	1.03	1.34			0.587	19.0
2038	$ 5.27	1.03	1.35			0.570	20.0
2039	$ 5.27	1.02	1.35			0.554	21.0
2040	$ 5.27	1.02	1.36			0.538	22.0
2041	$ 5.27	1.02	1.36	$ 62.87		0.522	23.0
2042	$ 5.27	1.01	1.37			0.507	24.0
2043	$ 5.27	1.01	1.38			0.492	25.0
2044	$ 5.27	1.00	1.39			0.478	26.0
2045	$ 5.27	1.00	1.40			0.464	27.0
2046	$ 5.27	1.00	1.41			0.450	28.0
2047	$ 5.27	1.00	1.42			0.437	29.0
2048	$ 5.27	1.00	1.43			0.424	30.0
2049	$ 5.27	0.99	1.45			0.412	0.0

Use **Tables od Section A** of the *Energy Price Indices and Discount Factors LCCA 2019, Annual Supplement to Handbook 135* (page 8) to find SPV and UPV factors.

Discount Payback Period Result: FEMP Project

First Positive Savings:	$	6.467
PAYBACK PERIOD:		4
FISCAL YEAR OF DISCOUNT PAYBACK:		2023

Note: Discount payback period measures the time of recovery to meet initial investment costs.

SUMMARY OF LIFE-CYCLE COST ANALYSIS

PROJECT IDENTIFICATION

Project Name:	??????
Fiscal year:	2019
Location:	TA 03-1420
Base Date (BD):	7/2/2019
Service Date (SD):	????????
Design feature to be Evaluated:	T8 lamps to LED lamps.
List Constraints:	None.
Energy/Water Conservation Study? (FEMP)	Yes
OMB A-94?	No

BASE CASE AND ALTERNATIVES

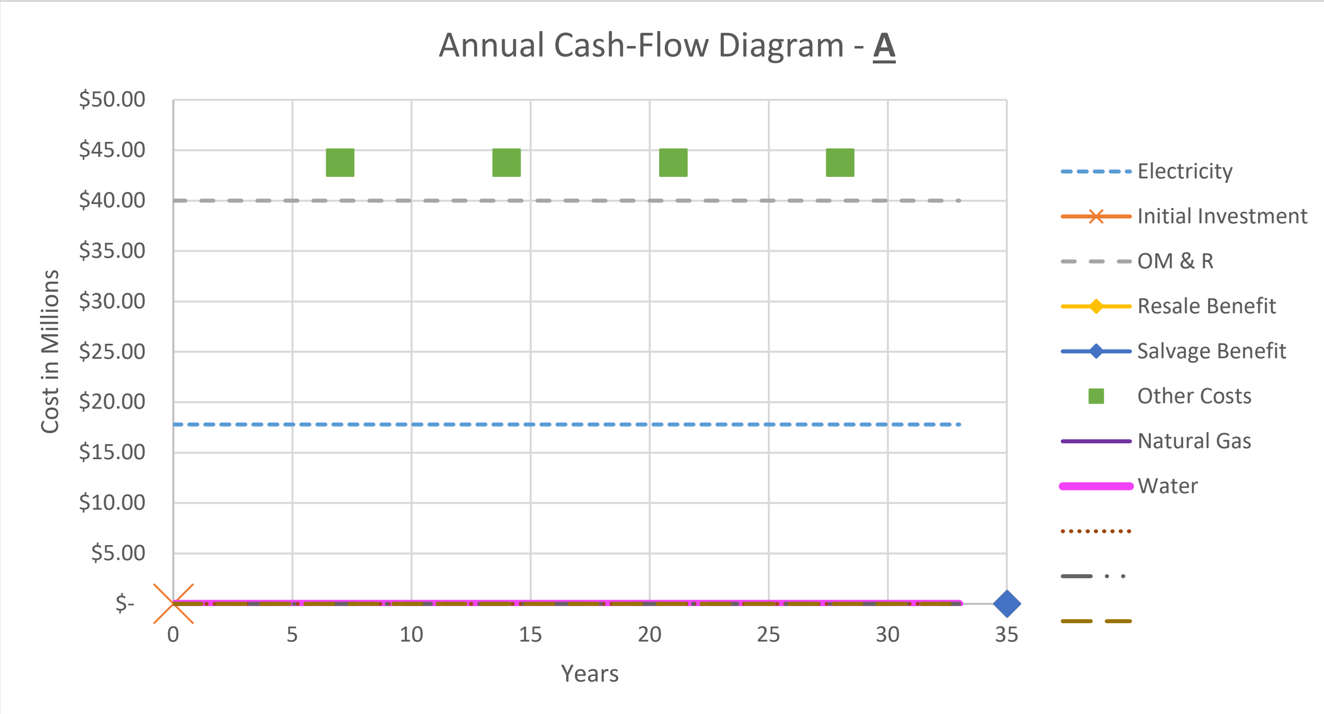
Name and describe base case and alternatives to be analyzed:

GENERAL INFORMATION:

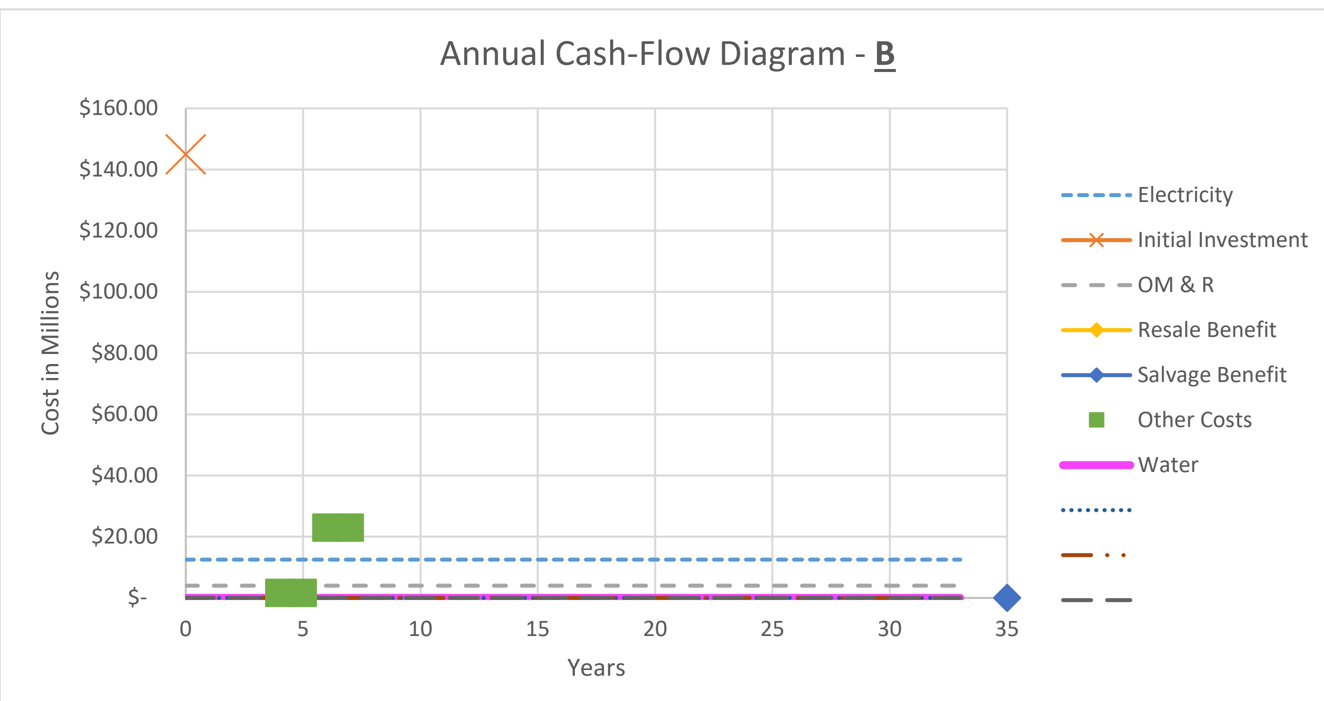
Name of Analyst:	
Phone Number:	
Z-Number:	
Date of Study Completion:	??/??/????

KEY DATES

Years of Life:	30
BD:	7/2/2019
SD:	????????
End of Study:	??/??/????



Total Case A Present Value Life Cycle Costs: $ 1,239.93



Total Case B Present Value Life Cycle Costs: $ 495.18

SAVINGS-TO-INVESTMENT RATIO:

Savings-to-Investments Ratio (SIR):	6.2921

DISCOUNT PAYBACK PERIOD: FEMP

Discount Payback Period:	4
Fiscal year of Discount Payback:	2023

B.3 FINAL LCCA TEMPLATE

Instructions:

This worksheet provides the LCCA comparison between two cases: Case A and Case B. The lifetime evalued is set at a maximum of 35 years. This worksheet is formatted to be printer-friendly, do not change this format. Only DOE projects may use this calculator (no OMB). The discount factors included for payback calcultions must be updated annually with the Annual Supplement to Handbook 135.

User must fill in each applicable yellow field input area. Notes are provided for clarity when inputting values. White areas are coded to provide Life-Cycle Cost Analysis (LCCA), do not interfere with these calculations.

The following result can be concluded from this worksheet: General project identificaiton information, cash flow comparisons (visual and numerical), savings-to-investment ratio, and discount payback period.

Terminology Clarifications:

"Year in lifetime" refers to the year at which the cost takes place.

For costs not listed that occur annually, add to highlighted space in "General & Cash Flow" tab where "all" is listed. For costs not listed that occur once, add to highlighted space in "General & Cash Flow" tab where the year must be specified. Specify the year at which the cost takes place in the provided space.

"One-Time Other Costs" refers to investment and operational costs that do not occur annually. For these values, the user will also list the "year in lifetime" in the corresponding input cell. Examples of these costs include replacements such as roofing, mechanical equiptment, etc.

"Lower-First-Cost Option" refers to the cost in a category belonging to the option with the lowest initial investment. *"Higher-First-Cost Option"* refers to the cost in a category belonging to the option with the highest initial investment.

Citations:

Life-Cycle Costing Manual for the Federal Energy Management Program, NIST Handbook 135, 1995 Edition:
https://www.nist.gov/publications/life-cycle-costing-manual-federal-energy-management-program-nist-handbook-135-1995

Energy Price Indices and Discount Factors LCCA 2019, Annual Supplement to Handbook 135 :
https://www.nist.gov/publications/energy-price-indices-and-discount-factors-life-cycle-cost-analysis-150-2019-annual

Utilities & Infrastructure Facility Operations, Los Alamos National Laboratory.
Author: Matney Juntunen

Initial Investment Calculator:

Instructions:	Fill in the following values if applicable to the project. The initial investment should include all costs which allow the project to begin its lifetime. **Note: Costs are in Thousands.**

CASE A INITIAL INVESTMENT:

TOPIC	**COST**
All Materials:	
All labor:	
TAB:	
BAS Controls:	
Safety:	
Inspections:	
Building Outage:	
Parking Lot:	
Water Drainage:	
Other Contruction Costs:	
Gas Extension Calulations:	
Case A Initial Investment:	**$ -**

CASE B INITIAL INVESTMENT:

TOPIC	**COST**
All Materials:	
All labor:	
TAB:	
BAS Controls:	
Safety:	
Inspections:	
Building Outage:	
Parking Lot:	
Water Drainage:	
Other Contruction Costs:	
Gas Extension Calulations:	
Case A Initial Investment:	**$ -**

Gasline and Water Calculations:

Gas Line Extension Calculations:		Notes:	
Linear measurement of extension (in feet):		For lines up to 10 inch diameter	
Cost of line per linear foot:	$ 0.40	Includes cost of construction, quoted 5/28/19	
Cost per tie-in:	$ 5.00		
Cost per reg station:	$ 5.00		
Number of tie-ins:			
Number of reg stations:			
Total Cost of Line Extension/Tie-Ins:		$ -	7/22/19

Annual Water Cost Calculations:		Notes:
Number of Office Workers:		
(in kilo-gallons):	0.025	Quoted 5/28/19
Needed (in kilo-gallons):		
Cost of Water (per kgal)	$ 0.00340000	Cost in thousands, quoted 5/28/19 at $3.40 per kgal
Total Annual Cost of Water:	$ -	

Information Needed to Complete this Workbook:

Case A Cost: (in Thousands)

CATEGORY	YEAR # IN LIFETIME	COST PER YEAR	Notes
Initial investment:	1	$ -	
Total Electricity:	Annual		(Usually $0.08 per kW/h)
OM & R:	Annual		Lifetime of 6 years = zero OM&R
Total Natural Gas:	Annual		(Usually $3.5 per million Btu)
Water:	Annual	$ -	
Resale value:			End of Life Expectancy
Salvage Value:			End of Life Expectancy

Case B Cost: (in Thousands)

CATEGORY	YEAR # IN LIFETIME	COST PER YEAR	Notes
Initial investment:	1	$ -	
Total Electricity:	Annual		(Usually $0.08 per kW/h)
OM & R:	Annual		Lifetime of 6 years = zero OM&R
Total Natural Gas:	Annual		(Usually $3.5 per million Btu)
Water:	Annual	$ -	
Resale value:			End of Life Expectancy
Salvage Value:			End of Life Expectancy

Cost of Gas vs. Electric LCC Analysis Calculator - See Appendix C in NIST Handbook 135 for Guidance

PROJECT IDENTIFICATION		Notes
Project ID No:		
Fiscal year:		
Location:		DoE Region, LANL Building
Base Date (BD):		MM/DD/YYYY (Start of study)
Service Date (SD):		MM/DD/YYYY (Occupancy)
Design Feature to be Evaluated:		
List Constraints:		Attach page if needed
Energy/Water Conservation Study? (FEMP)	No	
OMB A-94?	No	Office of Management and Budget circular not at LANL

BASE CASE AND ALTERNATIVES

Name and describe base case (lower initial investment) and alternatives to be analyzed. Include any relevent assumptions:

GENERAL INFORMATION:

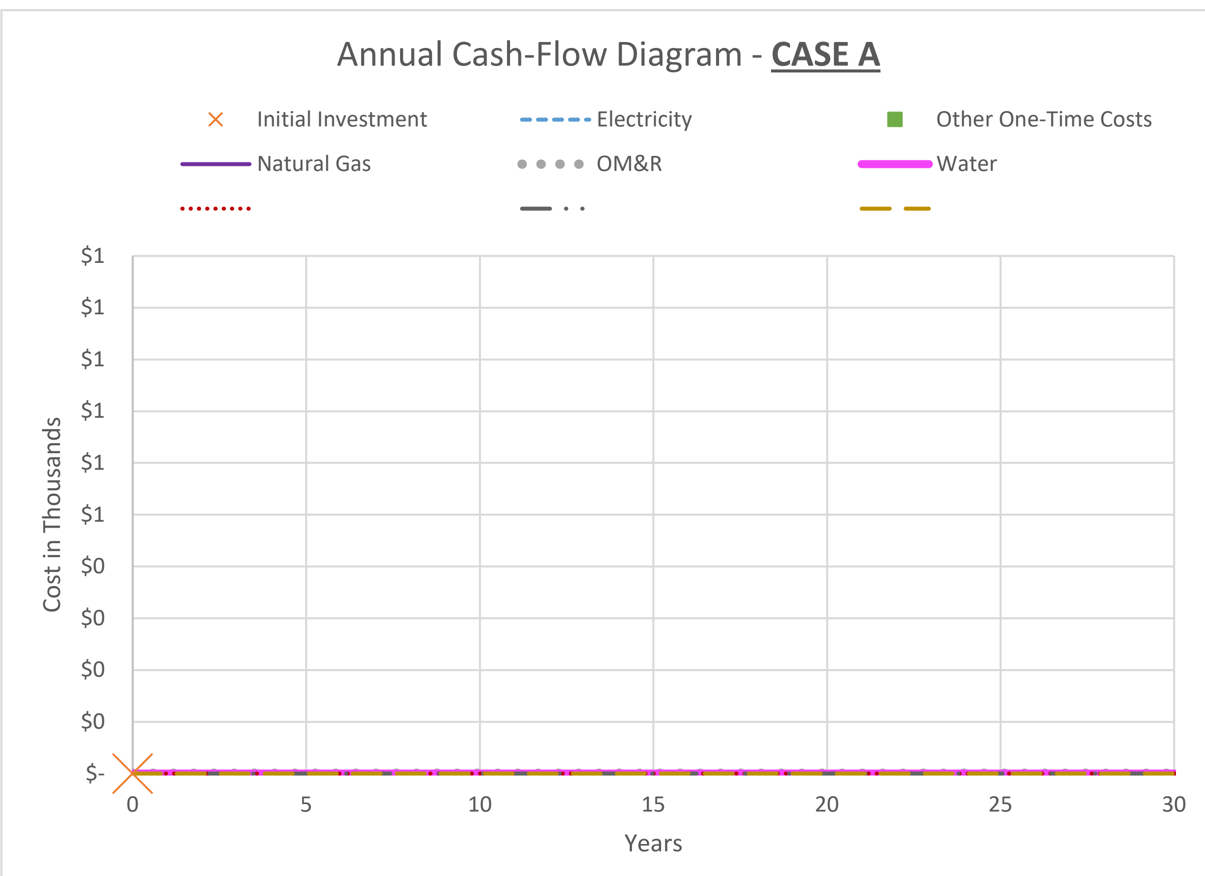
Name of Analyst:		
Phone Number:		
Z-Number:		
Date of Study Completion:		MM/DD/YYYY

KEY DATES		Notes
Years of Life:		Quantity (commonly 25-30 years)
BD:	1/0/1900	
SD:	1/0/1900	
End of Study:	1/0/1900	

Cash Flows Last Updated 7/23/2017

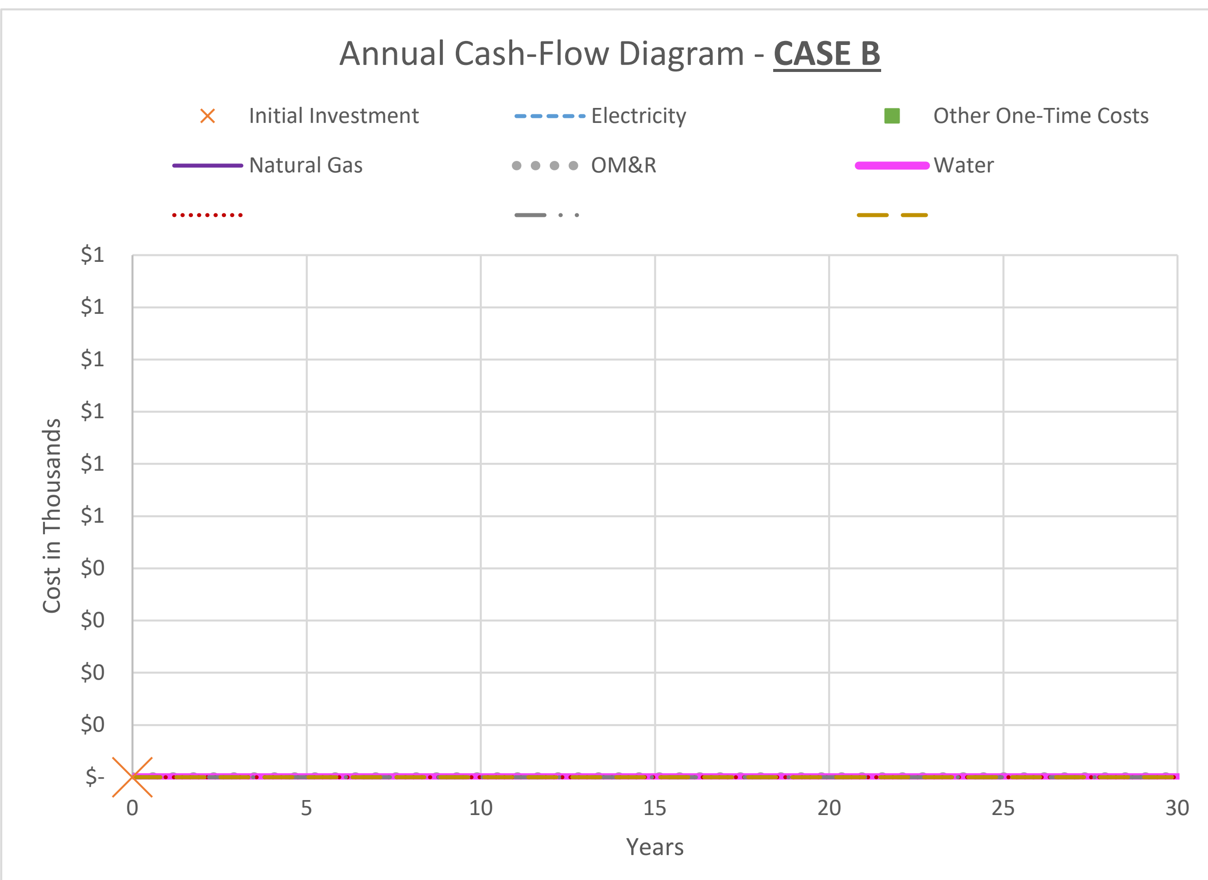
CASH FLOWS (IN THOUSANDS) FOR CASE A

CATEGORY	YEAR # IN LIFETIME	COST PER YEAR	Notes
Initial investment:	1	$ -	
Total Electricity:	Annual	$ -	(Usually $0.08 per kW/h)
OM & R:	Annual	$ -	
Total Natural Gas:	Annual	$ -	(Usually $3.5 per million Btu)
Water:	Annual	$ -	
	Annual		
	Annual		
	Annual		
			Other **One-Time** Costs (replacements, disposal, etc.)
Resale value:	0	$ -	End of Life Expectancy
Salvage Value:	0	$ -	End of Life Expectancy



CASH FLOWS (IN THOUSANDS) FOR CASE B

CATEGORY	YEAR # IN LIFETIME	COST		Notes
Initial investment:	1	$	-	
Total Electricity:	Annual	$	-	(Usually $0.08 per kW/h)
OM & R:	Annual	$	-	
Total Natural Gas:	Annual	$	-	(Usually $3.5 per million Btu)
Water	Annual	$	-	
	Annual			
	Annual			
	Annual			
				Other **One-Time** Costs (replacements, disposal, etc.)
Resale value:	0	$	-	End of Life Expectancy
Salve Value:	0	$	-	End of Life Expectancy



Colum	Column2	Column3	Column4	Column5	Column6	Column63	Column62	Column7	Column16	Column17
Data for Graphs - **Case B**										
Year	Init. Inv.	Electricity	OMR	Gas	Water	Other1	Other2	Other3	Resale	Salvage
0	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -		
3		$ -	$ -	$ -	$ -	$ -	$ -	$ -		
5		$ -	$ -	$ -	$ -	$ -	$ -	$ -		
7		$ -	$ -	$ -	$ -	$ -	$ -	$ -		
9		$ -	$ -	$ -	$ -	$ -	$ -	$ -		
11		$ -	$ -	$ -	$ -	$ -	$ -	$ -		
13		$ -	$ -	$ -	$ -	$ -	$ -	$ -		
15		$ -	$ -	$ -	$ -	$ -	$ -	$ -		
17		$ -	$ -	$ -	$ -	$ -	$ -	$ -		
19		$ -	$ -	$ -	$ -	$ -	$ -	$ -		
21		$ -	$ -	$ -	$ -	$ -	$ -	$ -		
23		$ -	$ -	$ -	$ -	$ -	$ -	$ -		
25		$ -	$ -	$ -	$ -	$ -	$ -	$ -		
27		$ -	$ -	$ -	$ -	$ -	$ -	$ -		
29		$ -	$ -	$ -	$ -	$ -	$ -	$ -		
31		$ -	$ -	$ -	$ -	$ -	$ -	$ -		
33		$ -	$ -	$ -	$ -	$ -	$ -	$ -		
35									$ -	$ -

Colur	Column2	Column3	Column4	Column5	Column6	Column7	Column8	Column9	Column10	Column11
Data for Graphs - **Case B**										
Year	Init. Inv.	Electricity	OMR	Water	Other1	Other2	Other3	Resale	Salvage	Nat Gas
0	$ -	$ -	$ -	$ -	$ -	$ -	$ -			$ -
3		$ -	$ -	$ -	$ -	$ -	$ -			$ -
5		$ -	$ -	$ -	$ -	$ -	$ -			$ -
7		$ -	$ -	$ -	$ -	$ -	$ -			$ -
9		$ -	$ -	$ -	$ -	$ -	$ -			$ -
11		$ -	$ -	$ -	$ -	$ -	$ -			$ -
13		$ -	$ -	$ -	$ -	$ -	$ -			$ -
15		$ -	$ -	$ -	$ -	$ -	$ -			$ -
17		$ -	$ -	$ -	$ -	$ -	$ -			$ -
19		$ -	$ -	$ -	$ -	$ -	$ -			$ -
21		$ -	$ -	$ -	$ -	$ -	$ -			$ -
23		$ -	$ -	$ -	$ -	$ -	$ -			$ -
25		$ -	$ -	$ -	$ -	$ -	$ -			$ -
27		$ -	$ -	$ -	$ -	$ -	$ -			$ -
29		$ -	$ -	$ -	$ -	$ -	$ -			$ -
31		$ -	$ -	$ -	$ -	$ -	$ -			$ -
33		$ -	$ -	$ -	$ -	$ -	$ -			$ -
35								$ -	$ -	

Specify Case A Investment-Related Costs: (in Thousands)

CATEGORY	AMOUNT	Notes	Year in Lifetime	DISCOUNT FACTOR (**SPV**)	Notes	PRESENT VALUE
Initial Investment:	$ -		1		(Rates included in NIST Handbook 135 Annual Suppliment discount factors. **Must discount to ending year of occurance**).	$ -
Resale:	$ -		0			$ -
Salvage:	$ -		0			$ -
		See previous sheet values and parts				$ -
						$ -
						$ -
						$ -
						$ -
						$ -

Total Investment-Related Costs: $ -

Specify Case A Operation-Related Costs: (in Thousands)

CATEGORY	AMOUNT	Notes	Year in lifetime/end year of occurances	DISCOUNT FACTOR (**UPV or SPV**)	Notes	PRESENT VALUE
Total Electricity:	$ -		0		(Rates included in NIST Handbook 135 Annual Suppliment discount factors. **Must discount to ending year of occurance**).	$ -
OM & R:	$ -		0			$ -
Total Natural Gas:	$ -		0			$ -
Water:	$ -		0			$ -
		See previous sheet values and parts				$ -
						$ -
						$ -
						$ -
						$ -

Total Operation-Related Costs: $ -

Total Case A Present Value Life Cycle Costs: $ -

Note: See Tables from the *Energy Price Indices and Discount Factors LCCA 2019, Annual Supplement to Handbook 135* to find discount factors.

UPV is for uniform/annual costs, while SPV is for single expense/one-time costs.

Specify Case B Investment-Related Costs: (in Thousands)

CATEGORY	AMOUNT	Notes	Year in Lifetime	DISCOUNT FACTOR (**SPV**)	FACTOR TABLE NO.	PRESENT VALUE
Initial Investment:	$ -		1		(Rates included in NIST Handbook 135 Annual Suppliment discount factors. **Must discount to ending year of occurance**).	$ -
Resale:	$ -		0			$ -
Salvage:	$ -		0			$ -
		See previous sheet values and parts				$ -
						$ -
						$ -
						$ -
						$ -
						$ -
			Total Investment-Related Costs:			$ -

Specify Case B Operation-Related Costs: (in Thousands)

CATEGORY	AMOUNT	Notes	Year in lifetime/end year of occurances	DISCOUNT FACTOR (**SPV or UPV**)	FACTOR TABLE NO.	PRESENT VALUE
Total Electricity:	$ -		0		(Rates included in NIST Handbook 135 Annual Suppliment discount factors. **Must discount to ending year of occurance**).	$ -
OM & R:	$ -		0			$ -
Natural Gas	$ -		0			$ -
Water	$ -		0			$ -
		See previous sheet values and parts				$ -
						$ -
						$ -
						$ -
						$ -
			Total Operation-Related Costs:			$ -

Total Case B Present Value Life Cycle Costs: $ -

Note: See Tables from the *Energy Price Indices and Discount Factors LCCA 2019, Annual Supplement to Handbook 135* to find discount factors.

UPV is for uniform/annual costs, while SPV is for single expense/one-time costs.

Calculate Savings-to-Investment Ratio:

Operational-Related Costs:	Lower-First-Cost Option	Higher-First-Cost Option	Savings
Total Energy:	$ -	$ -	$ -
OM & R:	$ -	$ -	$ -
Water:	$ -	$ -	$ -
Sum of Other Costs:	$ -	$ -	$ -
		Total Op. Savings (in Thousands):	**$ -**

Investment-Related Costs:	Higher-First-Cost Option	Lower-First-Cost Option	Savings
Initial Investment:	$ -	$ -	$ -
Resale+Salvage:	$ -	$ -	$ -
Sum of Other Costs:	$ -	$ -	$ -
		Total Additional Investment (in Thousands):	**$ -**

Savings-to-Investments Ratio (SIR): #DIV/0!

SIR is cost effective if the ratio is greater than 1. This measure is relative to the base case.

Discount Payback Period Calculation:

Table DPP1: CALCULATION OF DIFFERENTIAL AMOUNTS (IN THOUSANDS)				
Category:	Lower-First-Cost Option	Higher-First-Cost Option	Differential Amount	Notes
Initial Investment:	$ -	$ -	$ -	In dollars at time of Base Date (BD).
Total Energy:	$ -	$ -	$ -	
OM & R:	$ -	$ -	$ -	
Water:	$ -	$ -	$ -	
Sum of Other Annual Costs:	$ -	$ -	$ -	Gas/Elec Cost includes natural gas.
			$ -	User fills in **one-time cost** of same type. Place name in category column, and cost in appropriate column.
			$ -	
			$ -	
			$ -	
			$ -	
Resale/Salvage	$ -	$ -	$ -	
Note: The differential amounts above will be used in **Table DPP3** below				

Table DPP2: DOE CALCULATIONS (IN THOUSANDS)

Column1 Service Year	Column2 Annual Energy Savings	Column3 Change in OM&R, Water, and Other	Column4 Change in Capital Replacements	Column5 Present Value (PV) Savings DOE	Column6 Cumulative PV Savings	Column7 Change in PV Initial Investment	Column8 PV net savings
0	$ -	$ -	$ -	$ -	$ -	$ -	$ -
1	$ -	$ -	$ -	$ -	$ -	$ -	$ -
2	$ -	$ -	$ -	$ -	$ -	$ -	$ -
3	$ -	$ -	$ -	$ -	$ -	$ -	$ -
4	$ -	$ -	$ -	$ -	$ -	$ -	$ -
5	$ -	$ -	$ -	$ -	$ -	$ -	$ -
6	$ -	$ -	$ -	$ -	$ -	$ -	$ -
7	$ -	$ -	$ -	$ -	$ -	$ -	$ -
8	$ -	$ -	$ -	$ -	$ -	$ -	$ -
9	$ -	$ -	$ -	$ -	$ -	$ -	$ -
10	$ -	$ -	$ -	$ -	$ -	$ -	$ -
11	$ -	$ -	$ -	$ -	$ -	$ -	$ -
12	$ -	$ -	$ -	$ -	$ -	$ -	$ -
13	$ -	$ -	$ -	$ -	$ -	$ -	$ -
14	$ -	$ -	$ -	$ -	$ -	$ -	$ -
15	$ -	$ -	$ -	$ -	$ -	$ -	$ -
16	$ -	$ -	$ -	$ -	$ -	$ -	$ -
17	$ -	$ -	$ -	$ -	$ -	$ -	$ -
18	$ -	$ -	$ -	$ -	$ -	$ -	$ -
19	$ -	$ -	$ -	$ -	$ -	$ -	$ -
20	$ -	$ -	$ -	$ -	$ -	$ -	$ -
21	$ -	$ -	$ -	$ -	$ -	$ -	$ -
22	$ -	$ -	$ -	$ -	$ -	$ -	$ -
23	$ -	$ -	$ -	$ -	$ -	$ -	$ -
24	$ -	$ -	$ -	$ -	$ -	$ -	$ -
25	$ -	$ -	$ -	$ -	$ -	$ -	$ -
26	$ -	$ -	$ -	$ -	$ -	$ -	$ -
27	$ -	$ -	$ -	$ -	$ -	$ -	$ -
28	$ -	$ -	$ -	$ -	$ -	$ -	$ -
29	$ -	$ -	$ -	$ -	$ -	$ -	$ -
30	$ -	$ -	$ -	$ -	$ -	$ -	$ -
End of Lifetime							

Notes: Use tables **Ca-4** through **Ca-5** of the *Energy Price Indices and Discount Factors LCCA 2019, Annual Supplement to Handbook 135* (page 39) to calculate annual energy savings. https://www.nist.gov/publications/energy-price-indices-and-discount-factors-life-cycle-cost-analysis-

Table DPP3: CALCULATE COMPONENTS OF DPP CALCULATION TABLE ABOVE

Year	Energy Savings	Fuel Index - Commercial Electricity (2019)	Fuel Index - Commercial Natural Gas (2019)	Other One-Time Cost Differentials	<-- Notes	SPV Factor Index **DOE** Discount Rate (2019)	UPV Factor Index **DOE** Discount Rate (2019)
2019	$ -	1.00	1.00		User enters differential amount (Table DPP1, Column E) into correct year.	0.971	0.971
2020	$ -	0.96	1.01			0.971	0.971
2021	$ -	0.93	1.02			0.943	1.913
2022	$ -	0.94	1.03			0.915	2.829
2023	$ -	0.95	1.05			0.888	3.717
2024	$ -	0.96	1.06			0.863	4.580
2025	$ -	0.98	1.09			0.837	5.417
2026	$ -	1.00	1.10		A negative value is shown inside parentheses, and must be entered as negative in the input section.	0.813	6.230
2027	$ -	1.00	1.11			0.789	1.020
2028	$ -	1.00	1.12			0.766	7.786
2029	$ -	1.00	1.23			0.744	8.530
2030	$ -	1.01	1.27			0.722	9.253
2031	$ -	1.02	1.29			0.701	9.954
2032	$ -	1.02	1.30			0.681	10.635
2033	$ -	1.03	1.31			0.661	11.296
2034	$ -	1.02	1.32			0.642	11.938
2035	$ -	1.02	1.33			0.623	12.561
2036	$ -	1.03	1.34			0.605	13.166
2037	$ -	1.03	1.34			0.587	13.754
2038	$ -	1.03	1.35			0.570	14.324
2039	$ -	1.02	1.35			0.554	14.877
2040	$ -	1.02	1.36			0.538	15.415
2041	$ -	1.02	1.36			0.522	15.937
2042	$ -	1.01	1.37			0.507	16.444
2043	$ -	1.01	1.38			0.492	16.936
2044	$ -	1.00	1.39			0.478	17.413
2045	$ -	1.00	1.40			0.464	17.877
2046	$ -	1.00	1.41			0.450	18.327
2047	$ -	1.00	1.42			0.437	18.764
2048	$ -	1.00	1.43			0.424	19.188
2049	$ -	0.99	1.45			0.412	19.600

Use **Tables od Section A** of the *Energy Price Indices and Discount Factors LCCA 2019, Annual Supplement to Handbook 135* (page 8) to find SPV and UPV factors.

Discount Payback Period Result: FEMP Project

First Positive Savings:	$	-
PAYBACK PERIOD:		31
FISCAL YEAR OF DISCOUNT PAYBACK:		31

Note: Discount payback period measures the time of recovery to meet initial investment costs.

SUMMARY OF LIFE-CYCLE COST ANALYSIS

PROJECT IDENTIFICATION

Project Name:	0
Fiscal year:	0
Location:	0
Base Date (BD):	1/0/1900
Service Date (SD):	1/0/1900
Design feature to be Evaluated:	0
List Constraints:	0
Energy/Water Conservation Study? (FEMP)	Yes

BASE CASE AND ALTERNATIVES

Name and describe base case and alternatives to be analyzed. Include any relevent assumptions:

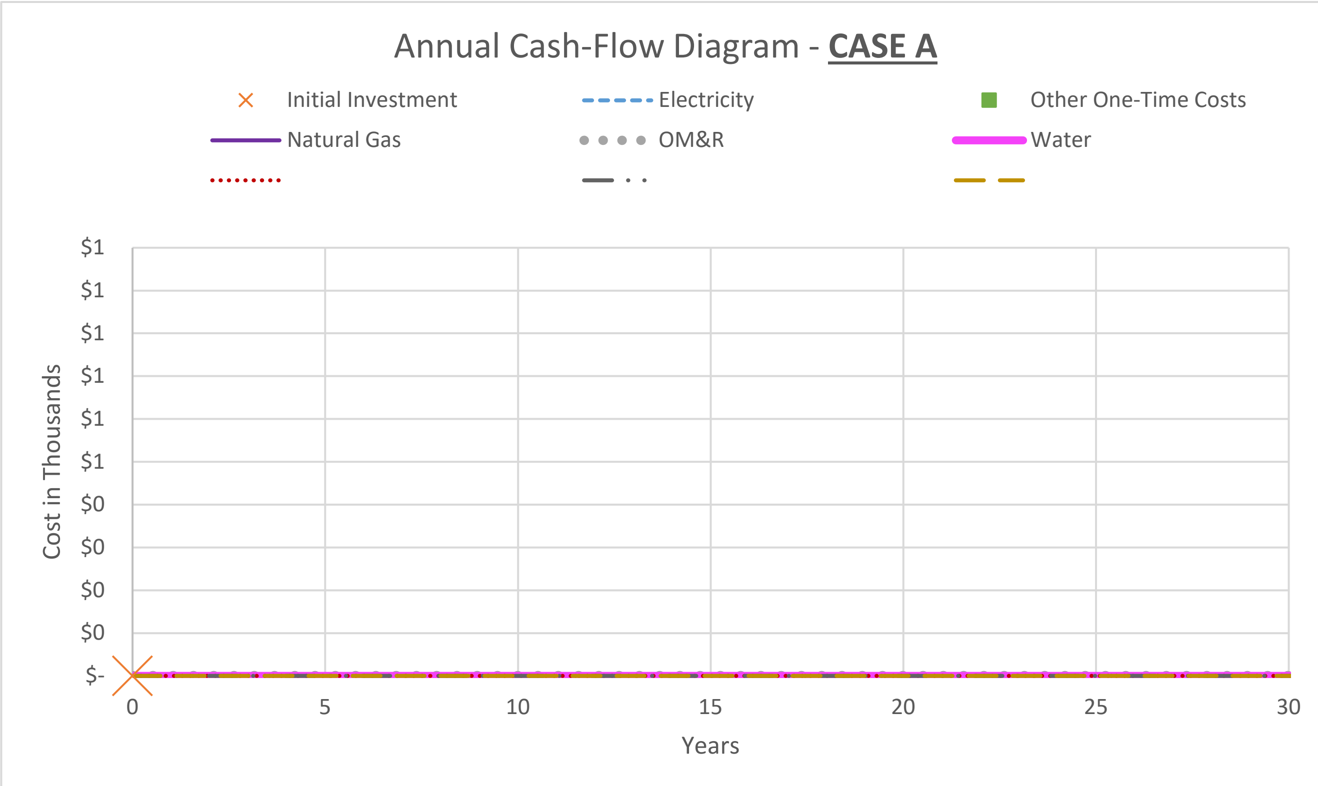
0

GENERAL INFORMATION:

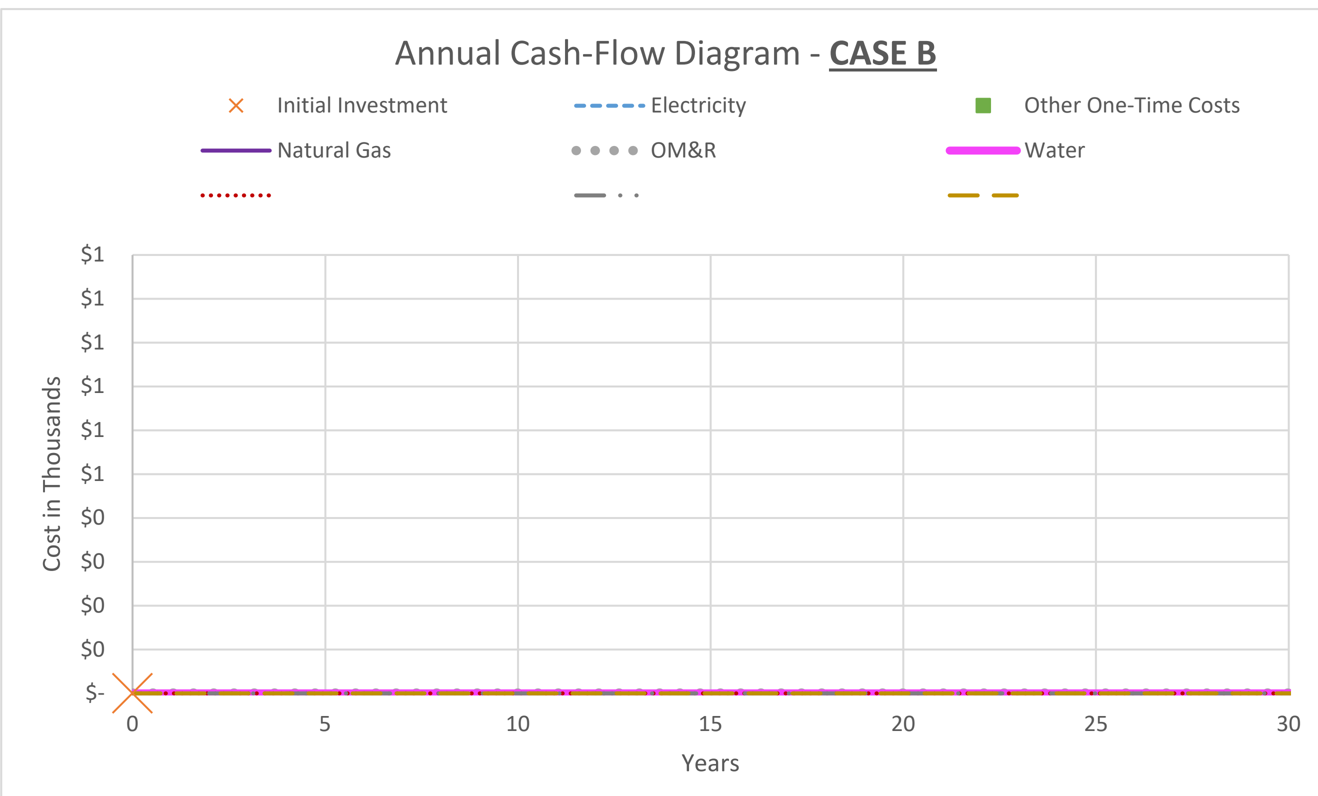
Name of Analyst:	0
Phone Number:	0
Z-Number:	0
Date of Study Completion:	1/0/1900

KEY DATES

Years of Life:	0
BD:	1/0/1900
SD:	1/0/1900
End of Study:	1/0/1900



Total Case A Present Value Life Cycle Costs: $ -



Total Case B Present Value Life Cycle Costs: $ -

SAVINGS-TO-INVESTMENT RATIO:

Savings-to-Investments Ratio (SIR):	#DIV/0!

DISCOUNT PAYBACK PERIOD: FEMP

Discount Payback Period:	31
Fiscal year of Discount Payback:	31

B.4 FINAL LCCA PRESENTATION

Utilities and Institutional Facilities

Life-Cycle Cost Analysis Excel Tool

Monica Witt and Matney Juntunen

August 8th, 2019

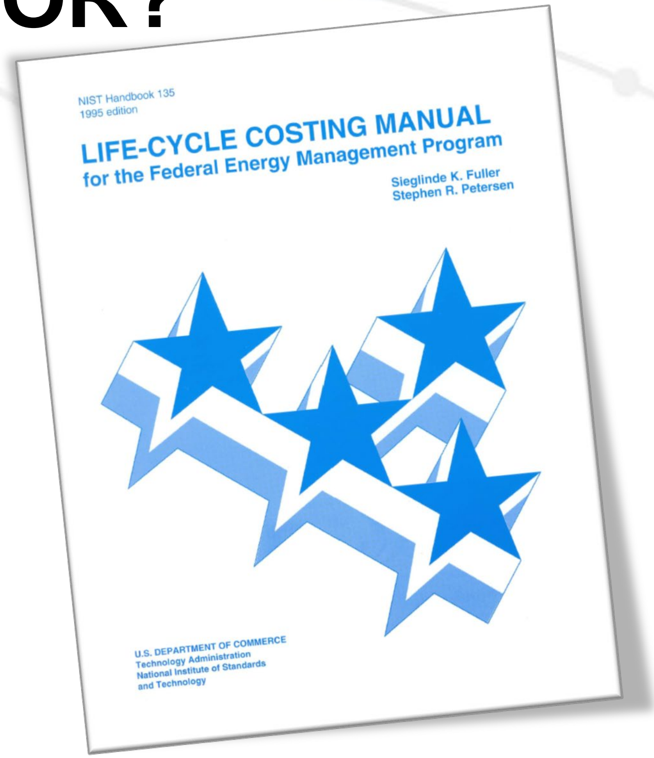
UNCLASSIFIED

Managed by Triad National Security, LLC for the U.S. Department of Energy's NNSA

LA-UR-YY-XXXXX

LCCA: WHY A CALCULATOR?

- LANL engineers struggling to commit time to thorough LCCA
- Required by Engineering Standards Manual STD-342-100
- Hand calculations are now automated and graphed, saving several hours
- Spreadsheet can be used for whole projects and components of projects



UTILITIES AND INSTITUTIONAL FACILITIES

We recognize the need for an easier way to perform LCCA at LANL.

CALCULATOR EXAMPLE:

Instructions:

This worksheet provides the LCCA comparison between two cases: Case A and Case B. The lifetime evalued is set at a maximum of 35 years. This worksheet is formatted to be printer-friendly, do not change this format. Only DOE projects may use this calculator (no OMB). The discount factors included for payback calcultions must be updated annually with the Annual Supplement to Handbook 135.

User must fill in each applicable yellow field input area. Notes are provided for clarity when inputting values. White areas are coded to provide Life-Cycle Cost Analysis (LCCA), do not interfere with these calculations.

The following result can be concluded from this worksheet: General project identificaiton information, cash flow comparisons (visual and numerical), savings-to-investment ratio, and discount payback period.

Terminology Clarifications:

"Year in lifetime" refers to the year at which the cost takes place.

For costs not listed that occur annually, add to highlighted space in "General & Cash Flow" tab where "all" is listed. For costs not listed that occur once, add to highlighted space in "General & Cash Flow" tab where the year must be specified. Specify the year at which the cost takes place in the provided space.

"One-Time Other Costs" refers to investment and operational costs that do not occur annually. For these values, the user will also list the "year in lifetime" in the corresponding input cell. Examples of these costs include replacements such as roofing, mechanical equiptment, etc.

"Lower-First-Cost Option" refers to the cost in a category belonging to the option with the lowest initial investment. *"Higher-First-Cost Option"* refers to the cost in a category belonging to the option with the highest initial investment.

Citations:

Life-Cycle Costing Manual for the Federal Energy Management Program, NIST Handbook 135, 1995 Edition:
https://www.nist.gov/publications/life-cycle-costing-manual-federal-energy-management-program-nist-handbook-135-1995

Energy Price Indices and Discount Factors LCCA 2019, Annual Supplement to Handbook 135 :
https://www.nist.gov/publications/energy-price-indices-and-discount-factors-life-cycle-cost-analysis-150-2019-annual

Author: Utilities & Infrastructure Facility Operations, Los Alamos National Laboratory.
Matney Juntunen

Initial Investment Calculator:

Instructions:	Fill in the following values if applicable to the project. The initial investment should include all costs which allow the project to begin its lifetime. **Note: Costs are in Thousands.**

Current State INITIAL INVESTMENT: TOPIC	COST	Smart Lab INITIAL INVESTMENT: TOPIC	COST
All Materials:		ERS Materials/Labor:	$ 276.19
All labor:		AHUs Materials/Labor:	$ 6.86
TAB:		TAB:	$ 15.00
BAS Controls:		BAS Controls:	$ 15.00
Safety:		Safety:	
Inspections:		Inspections:	
Building Outage:		Building Outage:	
Parking Lot:		Parking Lot:	
Water Drainage:		Water Drainage:	
Other Contruction Costs:		Other Contruction Costs:	
Gas Extension Calulations:		Gas Extension Calulations:	
		LED Lighting:	$ 144.93
		Lab ACH TAB and BAS:	$ 12.00
Case A Initial Investment:	$ -	**Case A Initial Investment:**	$ 469.98

Note: Gasket = $13.72 per LF

Gasline and Water Calculations:

Gas Line Extension Calculations:		Notes:
Linear measurement of extension (in feet):		For lines up to 10 inch diameter
Cost of line per linear foot:	$ 0.40	Includes cost of construction, quoted 5/28/19
Cost per tie-in:	$ 5.00	
Cost per reg station:	$ 5.00	
Number of tie-ins:		
Number of reg stations:		
Total Cost of Line Extension/Tie-Ins:	$ -	7/22/19

Annual Water Cost Calculations:		Notes:
Number of Office Workers:		
(in kilo-gallons):	0.025	Quoted 5/28/19
Needed (in kilo-gallons):		
Cost of Water (per kgal)	$ 0.00340000	Cost in thousands, quoted 5/28/19 at $3.40 per kgal
Total Annual Cost of Water:	$ -	

Los Alamos NATIONAL LABORATORY EST. 1943

NNSA National Nuclear Security Administration

CALCULATOR EXAMPLE CONT:

Information Needed to Complete this Workbook:

Current Cost: (in Thousands)

CATEGORY	YEAR # IN LIFETIME	COST PER YEAR	Notes
Initial investment:	1	$ -	
Total Electricity:	Annual	$ 117.29	(Usually $0.08 per kW/h)
OM & R:	Annual		Lifetime of 6 years = zero OM&R
Total Natural Gas:	Annual	$ 48.85	(Usually $3.5 per million Btu)
Water:	Annual	$ -	
Resale value:			End of Life Expectancy
Salvage Value:			End of Life Expectancy

Smart Lab Cost: (in Thousands)

CATEGORY	YEAR # IN LIFETIME	COST PER YEAR	Notes
Initial investment:	1	$ 469.98	
Total Electricity:	Annual	$ 107.91	(Usually $0.08 per kW/h)
OM & R:	Annual		Lifetime of 6 years = zero OM&R
Total Natural Gas:	Annual	$ 21.98	(Usually $3.5 per million Btu)
Water:	Annual	$ -	
Resale value:			End of Life Expectancy
Salvage Value:			End of Life Expectancy

Cost of Gas vs. Electric LCC Analysis Calculator

- See Appendix C in NIST Handbook 135 for Guidance

PROJECT IDENTIFICATION		Notes
Project ID No:	103849	
Fiscal year:	2019	
Location:	TA-03-1420	DoE Region, LANL Building
Base Date (BD):	7/24/2019	MM/DD/YYYY (Start of study)
Service Date (SD):	12/17/2019	MM/DD/YYYY (Occupancy)
Design Feature to be Evaluated:	HVAC and lighting renovation	
List Constraints:		Attach page if needed
Energy/Water Conservation Study? (FEMP)	No	
OMB A-94?	No	Office of Management and Budget circular not at LANL

BASE CASE AND ALTERNATIVES

Name and describe base case (lower initial investment) and alternatives to be analyzed. Include any relevent assumptions:

Comparing if the Smart Lab renovaiton should be implemented at CINT.

GENERAL INFORMATION:		
Name of Analyst:	Matney Juntunen	
Phone Number:	55-667-1975	
Z-Number:	341830	
Date of Study Completion:	8/2/2019	MM/DD/YYYY

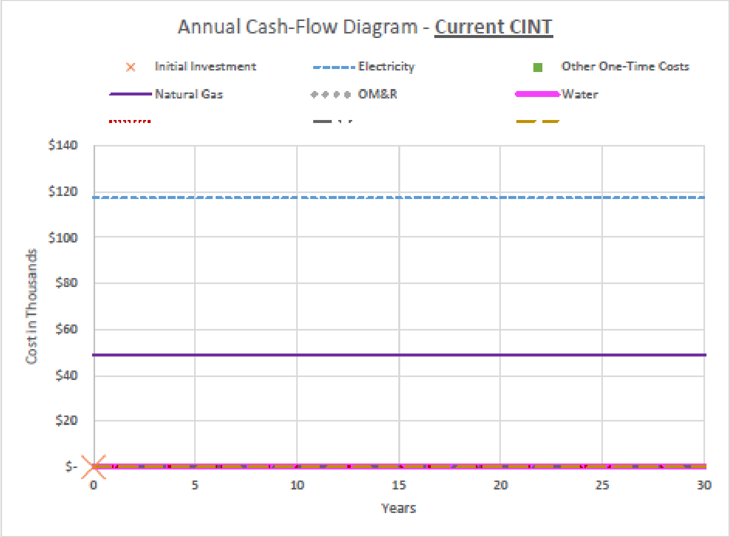
KEY DATES		Notes
Years of Life:	25	Quantity (commonly 25-30 years)
BD:	7/24/2019	
SD:	12/17/2019	
End of Study:	8/2/2019	

CALCULATOR EXAMPLE CONT:

Cash Flows Last Updated 7/23/2019

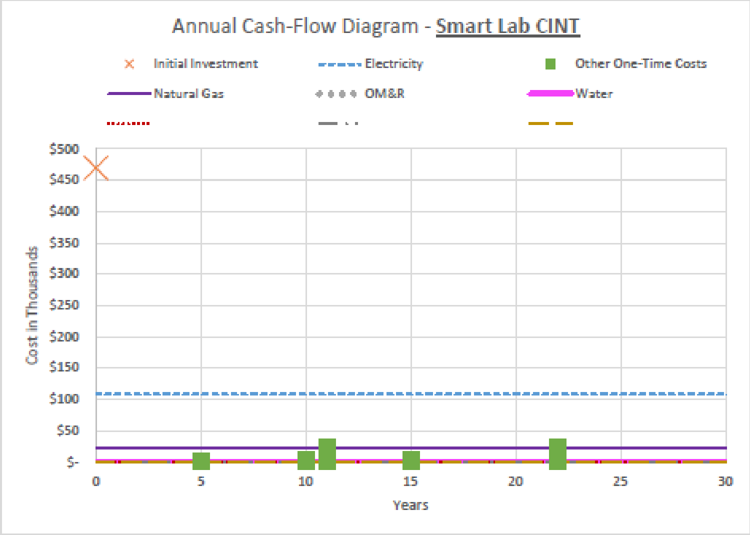
CASH FLOWS (IN THOUSANDS) FOR CASE A - Do Nothing

CATEGORY	YEAR # IN LIFETIME	COST PER YEAR	Notes
Initial investment:	1	$ -	
Total Electricity:	Annual	$ 117.29	(Usually $0.08 per kW/h)
OM & R:	Annual	$ -	
Total Natural Gas:	Annual	$ 48.85	(Usually $3.5 per million Btu)
Water:	Annual	$ -	
	Annual		
	Annual		
	Annual		
			Other One-Time Costs
Resale value:	0	$ -	End of Life Expectancy
Salvage Value:	0	$ -	End of Life Expectancy



CASH FLOWS (IN THOUSANDS) FOR CASE B - Smart Lab Changes

CATEGORY	YEAR # IN LIFETIME	COST	Notes
Initial investment:	1	$ 469.98	
Total Electricity:	Annual	$ 107.91	(Usually $0.08 per kW/h)
OM & R:	Annual	$ -	
Total Natural Gas:	Annual	$ 21.98	(Usually $3.5 per million Btu)
Water	Annual	$ -	
	Annual		
	Annual		
	Annual		
MERV 8 Filters	5	$ 0.9280	Other One-Time Costs
MERV 8 Filters	10	$ 0.9280	(replacements, disposal, etc.)
MERV 8 Filters	15	$ 0.9280	
Temp/Press Sensors	10	$ 2.30	
Pump Replacement	15	$ 3.95	
Bulb Recycle	11	$ 1.67	
Bulb Recycle	22	$ 1.67	
Bulb Replace	11	$ 23.00	
Bulb Replace	22	$ 23.00	
Resale value:	0	$ -	End of Life Expectancy
Salve Value:	0	$ -	End of Life Expectancy



CALCULATOR EXAMPLE CONT:

Case A Investment-Costs: (in Thousands)

CATEGORY	AMOUNT	Notes	Year in Lifetime	DISCOUNT FACTOR (SPV)	Notes	PRESENT VALUE
Initial Investment:	$ -		1		(Rates included in NIST Handbook 135 Annual Suppliment discount factors. **Must discount to ending year of**	$ -
Resale:	$ -		25			$ -
Salvage:	$ -		25			$ -
		See previous sheet values and parts				$ -
						$ -
						$ -
						$ -
						$ -
						$ -
					Total Investment-Related Costs:	$ -

Case A Operation-Related Costs: (in Thousands)

CATEGORY	AMOUNT	Notes	Year in lifetime/end year of occurances	FACTOR (UPV or SPV)	Notes	PRESENT VALUE
Total Electricity:	$ 117.29		25	1.02	(Rates included in NIST Handbook 135 Annual Suppliment discount factors. **Must discount to ending year of**	$ 119.63
OM & R:	$ -		25			$ -
Total Natural Gas:	$ 48.85		25	1.36		$ 66.43
Water:	$ -		25			$ -
		See previous sheet values and parts				$ -
						$ -
						$ -
						$ -
						$ -
					Total Operation-Related Costs:	$ 186.07

Total Case A Present Value Life Cycle Costs: $ 186.07

Note: See Tables from the *Energy Price Indices and Discount Factors LCCA 2019, Annual Supplement to Handbook 135* to find discount factors.

UPV is for uniform/annual costs, while SPV is for single expense/one-time costs.

Case B Investment-Related Costs: (in Thousands)

CATEGORY	AMOUNT	Notes	Year in Lifetime	DISCOUNT FACTOR (SPV)	FACTOR TABLE NO.	PRESENT VALUE
Initial Investment:	$ 469.98		1	0.971	(Rates included in NIST Handbook 135 Annual Suppliment discount factors. **Must discount to ending year of** occurance).	$ 456.35
Resale:	$ -		25			$ -
Salvage:	$ -		25			$ -
Bulb Replace	$ 23.00	See previous sheet values and parts	11	0.722		$ 16.61
Bulb Replace	$ 23.00		22	0.522		$ 12.01
						$ -
						$ -
						$ -
						$ -
						$ -
						$ -
						$ -
						$ -
			Total Investment-Related Costs:			$ 484.96

Case B Opoeration-Related Costs: (in Thousands)

CATEGORY	AMOUNT	Notes	Year in lifetime/end year of occurances	DISCOUNT FACTOR (SPV or UPV)	FACTOR TABLE NO.	PRESENT VALUE
Total Electricity:	$ 107.91		25	1.02	(Rates included in NIST Handbook 135 Annual Suppliment discount factors. **Must discount to ending year of** occurance).	$ 110.06
OM & R:	$ -		25			$ -
Natural Gas:	$ 21.98		20	1.36		$ 29.90
Water	$ -		25			$ -
MERV 8 Filters	$ 0.93	See previous sheet values and parts	5	0.863		$ 0.80
MERV 8 Filters	$ 0.93		10	0.744		$ 0.69
MERV 8 Filters	$ 0.93		15	0.642		$ 0.60
Temp/Press Sensors	$ 2.30		10	0.744		$ 1.71
Pump Replacement	$ 3.95		15	0.642		$ 2.54
Bulb Recycle	$ 1.67		11	0.722		$ 1.20
Bulb Recycle	$ 1.67		22	0.522		$ 0.87
						$ -
						$ -
			Total Operation-Related Costs:			$ 148.37

Total Case B Present Value Life Cycle Costs: $ 633.33

Note: See Tables from the *Energy Price Indices and Discount Factors LCCA 2019, Annual Supplement to Handbook 135* to find discount factors.
UPV is for uniform/annual costs, while SPV is for single expense/one-time costs.

CALCULATOR EXAMPLE CONT:

Calculate Savings-to-Investment Ratio:

Operational-Related Costs:	Lower-First-Cost Option	Higher-First-Cost Option	Savings
Total Energy:	$ 186.07	$ 139.96	$ 46.10
OM & R:	$ -	$ -	$ -
Water:	$ -	$ -	$ -
Sum of Other Costs:	$ -	$ 8.41	$ (8.41)
Total Op. Savings (in Thousands):			**$ 37.69**

Investment-Related Costs:	Higher-First-Cost Option	Lower-First-Cost Option	Savings
Initial Investment:	$ 456.35	$ -	$ 456.35
Resale+Salvage:	$ -	$ -	$ -
Sum of Other Costs:	$ 28.61	$ -	$ 28.61
Total Additional Investment (in Thousands):			**$ 484.96**

Savings-to-Investments Ratio (SIR): 0.0777

SIR is often preffered to be greater than 1. This measure is relative to the base case.

Discount Payback Period Calculation:

Table DPP1: CALCULATION OF DIFFERENTIAL AMOUNTS (IN THOUSANDS)

Category:	Lower-First-Cost Option	Higher-First-Cost Option	Differential Amount	Notes
Initial Investment:	$ -	$ 469.98	$ (469.98)	In dollars at time of Base Date (BD).
Total Energy:	$ 166.13	$ 129.89	$ 36.24	
OM & R:	$ -	$ -	$ -	
Water:	$ -	$ -	$ -	
Sum of Other Annual Costs:	$ -	$ -	$ -	Gas/Elec Cost includes natural gas.
Merv 8 Filters	$ -	$ 0.93	$ (0.93)	User fills in one-time cost of same type. Place name in category column, and cost in appropriate column.
Merv 8 Filters	$ -	$ 0.93	$ (0.93)	
Merv 8 Filters	$ -	$ 0.93	$ (0.93)	
Temp/Press Sensors	$ -	$ 2.30	$ (2.30)	
Pump Replacement	$ -	$ 3.95	$ (3.95)	
Bulb Recycle	$ -	$ 1.67	$ (1.67)	
Bulb Recycle	$ -	$ 1.67	$ (1.67)	
Bulb Replacement	$ -	$ 23.00	$ (23.00)	
Bulb Replacement	$ -	$ 23.00	$ (23.00)	
Resale/Salvage	$ -	$ -	$ -	

Note: The differential amounts above will be used in Table DPP3 below

CALCULATOR EXAMPLE CONT:

Table DPP2: DOE CALCULATIONS (IN THOUSANDS)

Column1 Service Year	Column2 Annual Energy Savings	Column3 Change in OM&R, Water, and Other	Column4 Change in Capital Replacements	Column5 Present Value (PV) Savings DOE	Column6 Cumulative PV Savings	Column7 Change in PV Initial Investment	Column8 PV net savings
2019	$ 36.245	$ -	$ -	$ 36.245	$ 36.245	$ (456.352)	$ (420.107)
2020	$ 35.701	$ -	$ -	$ 35.701	$ 71.946	$ (456.352)	$ (384.406)
2021	$ 35.339	$ -	$ -	$ 35.339	$ 107.284	$ (443.192)	$ (335.908)
2022	$ 35.701	$ -	$ -	$ 35.701	$ 142.985	$ (430.033)	$ (287.047)
2023	$ 36.245	$ -	$ (0.83)	$ 35.419	$ 178.404	$ (417.343)	$ (238.939)
2024	$ 36.607	$ -	$ -	$ 36.607	$ 215.011	$ (405.594)	$ (190.582)
2025	$ 37.513	$ -	$ -	$ 37.513	$ 252.525	$ (393.374)	$ (140.849)
2026	$ 38.057	$ -	$ -	$ 38.057	$ 290.582	$ (382.095)	$ (91.513)
2027	$ 38.238	$ -	$ -	$ 38.238	$ 328.820	$ (370.815)	$ (41.995)
2028	$ 38.419	$ -	$ (2.47)	$ 35.945	$ 364.765	$ (360.005)	$ 4.759
2029	$ 40.413	$ -	$ (18.35)	$ 22.058	$ 386.823	$ (349.666)	$ 37.157
2030	$ 41.319	$ -	$ -	$ 41.319	$ 428.142	$ (339.326)	$ 88.816
2031	$ 41.863	$ -	$ -	$ 41.863	$ 470.005	$ (329.457)	$ 140.548
2032	$ 42.044	$ -	$ -	$ 42.044	$ 512.049	$ (320.057)	$ 191.992
2033	$ 42.406	$ -	$ (3.23)	$ 39.181	$ 551.229	$ (310.657)	$ 240.572
2034	$ 42.406	$ -	$ -	$ 42.406	$ 593.636	$ (301.728)	$ 291.908
2035	$ 42.588	$ -	$ -	$ 42.588	$ 636.223	$ (292.798)	$ 343.425
2036	$ 42.950	$ -	$ -	$ 42.950	$ 679.173	$ (284.339)	$ 394.835
2037	$ 42.950	$ -	$ -	$ 42.950	$ 722.123	$ (275.879)	$ 446.244
2038	$ 43.131	$ -	$ -	$ 43.131	$ 765.254	$ (267.889)	$ 497.365
2039	$ 42.950	$ -	$ -	$ 42.950	$ 808.204	$ (260.369)	$ 547.835
2040	$ 43.131	$ -	$ (13.27)	$ 29.859	$ 838.063	$ (252.850)	$ 585.213
2041	$ 43.131	$ -	$ -	$ 43.131	$ 881.194	$ (245.330)	$ 635.864
2042	$ 43.131	$ -	$ -	$ 43.131	$ 924.325	$ (238.280)	$ 686.045
2043	$ 43.312	$ -	$ -	$ 43.312	$ 967.638	$ (231.231)	$ 736.407
2044	$ 43.312	$ -	$ -	$ 43.312	$ 1,010.950	$ (224.651)	$ 786.299
2045	$ 43.494	$ -	$ -	$ 43.494	$ 1,054.444	$ (218.071)	$ 836.373
2046	$ 43.675	$ -	$ -	$ 43.675	$ 1,098.119	$ (211.491)	$ 886.627
2047	$ 43.856	$ -	$ -	$ 43.856	$ 1,141.975	$ (205.382)	$ 936.593
2048	$ 44.037	$ -	$ -	$ 44.037	$ 1,186.012	$ (199.272)	$ 986.740
2049	$ 44.219	$ -	$ -	$ 44.219	$ 1,230.231	$ (193.632)	$ 1,036.598
End of Lifetime							

Notes: Use tables **Ca-4** through **Ca-5** of the *Energy Price Indices and Discount Factors LCCA 2019, Annual Supplement to Handbook 135* (page 39) to calculate annual energy savings.
https://www.nist.gov/publications/energy-price-indices-and-discount-factors-life-cycle-cost-analysis-

Table DPP3: CALCULATE COMPONENTS OF DPP CALCULATION TABLE ABOVE

Year	Energy Savings	Fuel Index - Commercial Electricity (2019)	Fuel Index - Commercial Natural Gas (2019)	Other One-Time Cost Differentials	<-- Notes	SPV Factor Index DOE Discount Rate (2019)	UPV Factor Index DOE Discount Rate (2019)
2019	$ 36.24	1.00	1.00		User enters	0.971	0.971
2020	$ 36.24	0.96	1.01		differential	0.971	0.971
2021	$ 36.24	0.93	1.02		amount (Table	0.943	1.913
2022	$ 36.24	0.94	1.03		DPP1, Column	0.915	2.829
2023	$ 36.24	0.95	1.05	$ (0.93)	E) into correct year.	0.888	3.717
2024	$ 36.24	0.96	1.06			0.863	4.580
2025	$ 36.24	0.98	1.09			0.837	5.417
2026	$ 36.24	1.00	1.10		A negative	0.813	6.230
2027	$ 36.24	1.00	1.11		value is shown	0.789	1.020
2028	$ 36.24	1.00	1.12	$ (3.23)	inside	0.766	7.786
2029	$ 36.24	1.00	1.23	$ (24.67)	parentheses,	0.744	8.530
2030	$ 36.24	1.01	1.27		and must be	0.722	9.253
2031	$ 36.24	1.02	1.29		entered as	0.701	9.954
2032	$ 36.24	1.02	1.30		negative in the input section.	0.681	10.635
2033	$ 36.24	1.03	1.31	$ (4.88)		0.661	11.296
2034	$ 36.24	1.02	1.32			0.642	11.938
2035	$ 36.24	1.02	1.33			0.623	12.561
2036	$ 36.24	1.03	1.34			0.605	13.166
2037	$ 36.24	1.03	1.34			0.587	13.754
2038	$ 36.24	1.03	1.35			0.570	14.324
2039	$ 36.24	1.02	1.35			0.554	14.877
2040	$ 36.24	1.02	1.36	$ (24.67)		0.538	15.415
2041	$ 36.24	1.02	1.36			0.522	15.937
2042	$ 36.24	1.01	1.37			0.507	16.444
2043	$ 36.24	1.01	1.38			0.492	16.936
2044	$ 36.24	1.00	1.39			0.478	17.413
2045	$ 36.24	1.00	1.40			0.464	17.877
2046	$ 36.24	1.00	1.41			0.450	18.327
2047	$ 36.24	1.00	1.42			0.437	18.764
2048	$ 36.24	1.00	1.43			0.424	19.188
2049	$ 36.24	0.99	1.45			0.412	19.600

Use **Tables od Section A** of the *Energy Price Indices and Discount Factors LCCA 2019, Annual Supplement to Handbook 135* (page 8) to find SPV and UPV factors.

CALCULATOR EXAMPLE CONT:

Table DPP2: DOE CALCULATIONS (IN THOUSANDS)

Column	Column2	Column3	Column4	Column5	Column6	Column7	Column8
Service Year	Annual Energy Savings	Change in OM&R, Water, and Other	Change in Capital Replacements	Present Value (PV) Savings DOE	Cumulative PV Savings	Change in PV Initial Investment	PV net savings
2019	$ 36.245	$ -	$ -	$ 36.245	$ 36.245	$ (456.352)	$ (420.107)
2020	$ 35.701	$ -	$ -	$ 35.701	$ 71.946	$ (456.352)	$ (384.406)
2021	$ 35.339	$ -	$ -	$ 35.339	$ 107.284	$ (443.192)	$ (335.908)
2022	$ 35.701	$ -	$ -	$ 35.701	$ 142.985	$ (430.033)	$ (287.047)
2023	$ 36.245	$ -	$ (0.83)	$ 35.419	$ 178.404	$ (417.343)	$ (238.939)
2024	$ 36.607	$ -	$ -	$ 36.607	$ 215.011	$ (405.594)	$ (190.582)
2025	$ 37.513	$ -	$ -	$ 37.513	$ 252.525	$ (393.374)	$ (140.849)
2026	$ 38.057	$ -	$ -	$ 38.057	$ 290.582	$ (382.095)	$ (91.513)
2027	$ 38.238	$ -	$ -	$ 38.238	$ 328.820	$ (370.815)	$ (41.995)
2028	$ 38.419	$ -	$ (2.47)	$ 35.945	$ 364.765	$ (360.005)	$ 4.759
2029	$ 40.413	$ -	$ (18.35)	$ 22.058	$ 386.823	$ (349.666)	$ 37.157
2030	$ 41.319	$ -	$ -	$ 41.319	$ 428.142	$ (339.326)	$ 88.816
2031	$ 41.863	$ -	$ -	$ 41.863	$ 470.005	$ (329.457)	$ 140.548
2032	$ 42.044	$ -	$ -	$ 42.044	$ 512.049	$ (320.057)	$ 191.992
2033	$ 42.406	$ -	$ (3.23)	$ 39.181	$ 551.229	$ (310.657)	$ 240.572
2034	$ 42.406	$ -	$ -	$ 42.406	$ 593.636	$ (301.728)	$ 291.908
2035	$ 42.588	$ -	$ -	$ 42.588	$ 636.223	$ (292.798)	$ 343.425
2036	$ 42.950	$ -	$ -	$ 42.950	$ 679.173	$ (284.339)	$ 394.835
2037	$ 42.950	$ -	$ -	$ 42.950	$ 722.123	$ (275.879)	$ 446.244
2038	$ 43.131	$ -	$ -	$ 43.131	$ 765.254	$ (267.889)	$ 497.365
2039	$ 42.950	$ -	$ -	$ 42.950	$ 808.204	$ (260.369)	$ 547.835
2040	$ 43.131	$ -	$ (13.27)	$ 29.859	$ 838.063	$ (252.850)	$ 585.213
2041	$ 43.131	$ -	$ -	$ 43.131	$ 881.194	$ (245.330)	$ 635.864
2042	$ 43.131	$ -	$ -	$ 43.131	$ 924.325	$ (238.280)	$ 686.045
2043	$ 43.312	$ -	$ -	$ 43.312	$ 967.638	$ (231.231)	$ 736.407
2044	$ 43.312	$ -	$ -	$ 43.312	$ 1,010.950	$ (224.651)	$ 786.299
2045	$ 43.494	$ -	$ -	$ 43.494	$ 1,054.444	$ (218.071)	$ 836.373
2046	$ 43.675	$ -	$ -	$ 43.675	$ 1,098.119	$ (211.491)	$ 886.627
2047	$ 43.856	$ -	$ -	$ 43.856	$ 1,141.975	$ (205.382)	$ 936.593
2048	$ 44.037	$ -	$ -	$ 44.037	$ 1,186.012	$ (199.272)	$ 986.740
2049	$ 44.219	$ -	$ -	$ 44.219	$ 1,230.231	$ (193.632)	$ 1,036.598
End of Lifetime							

Notes: Use tables Ca-4 through Ca-5 of the *Energy Price Indices and Discount Factors LCCA 2019, Annual Supplement to Handbook 135* (page 39) to calculate annual energy savings.
https://www.nist.gov/publications/energy-price-indices-and-discount-factors-life-cycle-cost-analysis-

Discount Payback Period Result: FEMP Project	
First Positive Savings:	$ 4.759
PAYBACK PERIOD:	10
FISCAL YEAR OF DISCOUNT PAYBACK:	2029

Note: Discount payback period measures the time of recovery to meet initial investment costs.

CALCULATOR EXAMPLE CONT:

SUMMARY OF LIFE-CYCLE COST ANALYSIS

PROJECT IDENTIFICATION

Project Name:	103849
Fiscal year:	2019
Location:	TA-03-1420
Base Date (BD):	7/24/2019
Service Date (SD):	12/17/2019
Design feature to be Evaluated:	HVAC and lighting renovation
List Constraints:	0
Energy/Water Conservation Study? (FEMP)	Yes

BASE CASE AND ALTERNATIVES

Name and describe base case and alternatives to be analyzed. Include any relevent assumptions:

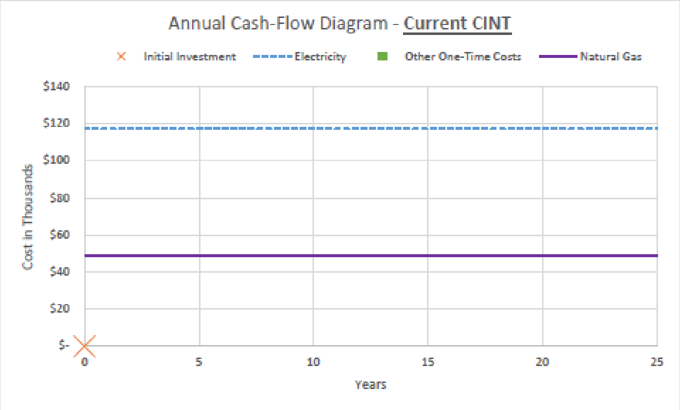
Comparing if the Smart Lab renovaiton should be implemented at CINT.

GENERAL INFORMATION:

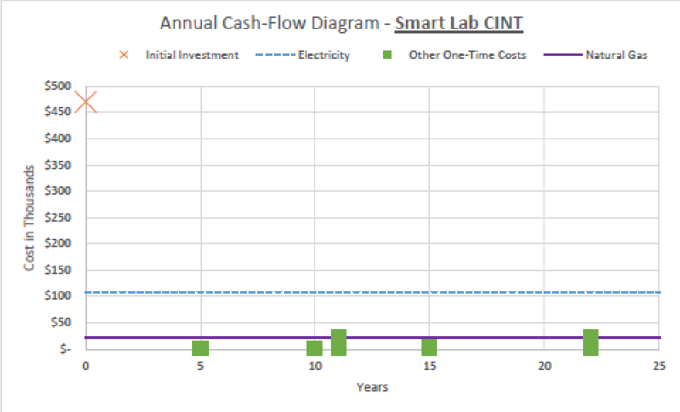
Name of Analyst:	Matney Juntunen
Phone Number:	55-667-1975
Z-Number:	341830
Date of Study Completion:	8/2/2019

KEY DATES

Years of Life:	25
BD:	7/24/2019
SD:	12/17/2019
End of Study:	8/2/2019



Current CINT Present Value Life Cycle Costs: $ 186.07



Total Smart Lab Present Value Life Cycle Costs: $ 633.33

SAVINGS-TO-INVESTMENT RATIO:

Savings-to-Investments Ratio (SIR): 0.0777

DISCOUNT PAYBACK PERIOD: FEMP

Discount Payback Period:	10
Fiscal year of Discount Payback:	2029

Questions?

APPENDIX C: TA-03-0223 HVAC CALCULATIONS

C.1 TA-03-0223 HEAT LOAD CALCULATIONS/ASSUMPTIONS (ASHRAE)

HVAC Load Calculations

Based on 1997 ASHRAE Handbook CLTD/SCL/CLF Method

Project:	TA-03-0223
Project No.:	?
Date:	July 12, 2019
Calcs By:	Matney Juntunen
Block or Terminal Loads	?

Total HVU2 Cool Demand:	128,950.75	BTU/Hr
Total HVU2 Cool Demand:	6,790.46	CFM

Unit Selectior	10.75	Ton AHU

INPUT

General Data

Project Location:	AC and Heat Unit	
Project Latitude:		deg. N.
Weather Data Source	2017 ASHRAE Handbook of Fundamentals, Chapter 14	
Summer Criteria	1.0	% Occurance
Winter Criteria	99.6	% Occurance
Safety Factor - Cooling	0	%
Safety Factor - Heating	25	%

Summer Dry bulb (F):	89
Summer Relative Humidity:	0.3
Summer design temp indoors:	75
Summer Delta Enthalpy:	4.22

System Description	AC and Heat Unit	
Summer Outside Design Temerature	89	degF
Inside Summer Design Temperature	75	degF (Default value)
Summer SA Temperature	55	degF
Winter Outside Design Temerature	5	degF
Inside Winter Design Temperature	72	degF (Default value)
Max. Winter SA Temperature	95	degF
Min. SA Airflow Percentage	30	%
Infiltration - Air Change Method	0.25	Air Changes/Hr
Infiltration - Air Leakage Method	0.05	CFM/sf of Wall/Glass surface
People - Sensible Heat	250	BTU/Hr/ Person
People - Latent Heat	160	BTU/Hr/ Person

Office
Conference/Break
Min. Ventilation

Room Data	System Totals	2 Vending, 2 Fridge, 1 Ice, oven, 2 micro, 1 coffee, 1 copy, 1 dt, 1 proj, 32 ppl, 1 drinking	2 ppl, miniF, coffee, sm printer, 1 comp, 2 mon	2 ppl, sm printer, 1 comp, 2 mon	5 mon, 2 ppl, 2 comp, 1 comp, 1 mon, 10 ppl, Lg TV	Bathroom	3 ppl, sm printer, 1 comp, 2 mon, miniF	miniF, 6 mon, 5 comp, battery charging, 5 ppl	Hall/Elec	Lg. Bathroom	Single Bathroom
Room No.:		106A	102A	102	101 + Conf	101A	101B	100	110/110A	113	114
Room Name:											
Peak Cooling Month		7	7	7	7	7	7	7	7	7	7
Peak Cooling Time		1400	1400	1400	1400	1400	1400	1400	1400	1400	1400
Summer Inside Temp (^oF)		75	75	75	75	75	75	75	75	75	75
Winter Inside Temp (^oF)		72	72	72	72	72	72	72	72	72	72
Safety Factor - Summer (%)		0	0	0	0	0	0	0	0	0	0
Safety Factor - Winter (%)		25	25	25	25	25	25	25	25	25	25
Room Width (ft)											
Room Length (ft)											
Room Height (ft)		9	9	9	9	9	9	9	9	9	9
Room Floor Area (sf)	3,204	1,220	102	102	583	82	165	489	241	177	43
Room Volume (ft^3)	28,836	10,980	918	918	5,247	738	1,485	4,401	2,169	1,593	387
Ceiling/Parition 1 - Room Name											
Ceiling/Patition 1 Area (sf)	0										
Parition Summer Temp (^oF)											
Parition Winter Temp (^oF)											
Parition 2 - Room Name											
Patition 2 Area (sf)	0										
Parition 2 Summer Temp (^oF)											
Parition 2 Winter Temp (^oF)											
Parition 3 - Room Name											
Patition 3 Area (sf)	0										
Parition 3 Summer Temp (^oF)											
Parition 3 Winter Temp (^oF)											
Roof Net Area (sf)	3,204	1,220	102	102	583	82	165	489	241	177	43
Skylight Area (sf)	0										
Exposed Floor Area:	3,204	1,220	102	102	583	82	165	489	241	177	43
Slab Edge Length (ft)	0										
Below Gr Wall Area (sf)	0										
Below Gr. Floor Area (sf)	0										
Wall 1 Direction (N, NE..)		S	N		N		N		S		
Wall 1 Net Area (sf)	441	153	45		63		54		126		
Fenestration 1 Area (sf)	64	16	16				16		16		
Fenestration 1 Infilration (cfm)	0										
Door 1 Area (sf)	0										
Door 1 Infiltration (cfm)	775	100	75	75	75	75	75	75	75	75	75
Wall 2 Direction (N, NE..)		S							S		
Wall 2 Net Area (sf)	279	153							126		
Fenestration 2 Area (sf)	32	16							16		
Fenestration 2 Infilration (cfm)	0										
Door 2 Area (sf)	0										
Door 2 Infiltration (cfm)	0										
Wall 3 Direction (N, NE..)		S									
Wall 3 Net Area (sf)	153	153									
Fenestration 3 Area (sf)	16	16									
Fenestration 3 Infilration (cfm)	0										
Door 3 Area (sf)	0										
Door 3 Infiltration (cfm)	0										
Wall 4 Direction (N, NE..)		S									
Wall 4 Net Area (sf)	153	153									
Fenestration 4 Area (sf)	16	16									
Fenestration 4 Infilration (cfm)	0										
Door 4 Area (sf)	0										
Door 4 Infiltration (cfm)	0										
People Type 1 - BTUH/Per. - Sensible		250	250	250	250	250	250	250	250	250	250
People Type 1 - BTUH/Per. - latent		160	160	160	160	160	160	160	160	160	160
No. of People - Type 1		32	2	2	12	0	3	5	0	0	0
People/1000 sf - Type 1											
People Type 2 - BTUH/Per. - Sensible											
People Type 2 - BTUH/Per. - latent											

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HVAC Calculations

Room No.:		106A	102A	102	101 + Conf	101A	101B	100	110/110A	113	114
Room Name:											
No. of People - Type 2											
People/1000 sf - Type 2											
Total No. of People	56	32	2	2	12	0	3	5	0	0	0
Lights (Watts) -Type 1		1008	336	336	840	84	336	1872	168	252	84
LIghts (Watts/sf) - Type 1			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% of Lights to Space (0-100%) - Type 1		60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%	60.0%
Lights (Watts) - Type 2											
LIghts (Watts/sf) - Type 2			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
% of Lights to Space (0-100%) - Type 2		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Tot. Lighting Watts to Space	3,194	605	202	202	504	51	202	1124	101	152	51
Tot.Lighting Watts to Plenum	3,317	403	196	196	686	83	233	1042	212	207	59
Equipment 1 (watts) **- Technology**		1525	217.75	217.75	690		217.75	800			
Equipment 1 (BTU/H Sens.)											
Equipment 1 (BTU/H Lat.)											
Equipment 2 (watts) **- Kitchen Related**		15910	1400				300	300			
Equipment 2 (BTU/H Sens.)											
Equipment 2 (BTU/H Lat.)											
Equipment 3 (watts) **- Other**		2810									
Equipment 3 (BTU/H Sens.)											
Equipment 3 (BTU/H Lat.)											
Total Equip.(BTU/H Sens.)	83,164	69035.45	5516.5275	742.5275	2352.9	0	1765.5275	3751	0	0	0
Total Equip.(BTU/H Lat.)	0	0	0	0	0	0	0	0	0	0	0

Summer U-factor Data

	106A	102A	102	101 + Conf	101A	101B	100	110/110A	113	114
Roof	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.38	0.24	0.24
Skylight										
Exposed Floor	0.53	0.39	0.39	0.39	0.53	0.39	0.39	0.53	0.53	0.53
Wall 1- Exterior	0.02			0.02		0.02		0.02		
Wall 2										
Wall 3										
Wall 4										
Fenestration 1	0.41	0.41				0.41		0.41		
Fenestration 2	0.41							0.41		
Fenestration 3	0.41							0.41		
Fenestration 4	0.41									
Door 1										
Door 2										
Door 3										
Door 4										
Ceiling/Partition 1										
Partition 2										
Partition 3										

Winter U-factor Data

	106A	102A	102	101 + Conf	101A	101B	100	110/110A	113	114
Roof										
Skylight										
Exposed Floor										
Slab Edge (BTU/Hr-F-LF)										
Below Gr. Walls (BTU/Hr-F-SF)										
Below Gr. Floors (BTU/H-SF)										
Wall 1										
Wall 2										
Wall 3										
Wall 4										
Fenestration 1										
Fenestration 2										
Fenestration 3										
Fenestration 4										
Door 1										
Door 2										
Door 3										
Door 4										
Ceiling/Partition 1										
Partition 2										
Partition 3										

CLTD (Cooling Load Temperature Difference) Values

	106A	102A	102	101 + Conf	101A	101B	100	110/110A	113	114
Roof	85	85	85	85	85	85	85	85	85	85
Wall 1	39	24		24		24		39		
Wall 2										
Wall 3										
Wall 4										
Fenestration 1	14	14				14				
Fenestration 2										
Fenestration 3										
Fenestration 4										
Door 1										
Door 2										
Door 3										
Door 4										

SC (Solar Coefficient glass) x IAC (shading) Values

	106A	102A	102	101 + Conf	101A	101B	100	110/110A	113	114
Skylight										
Fenestration 1										
Fenestration 2										
Fenestration 3										
Fenestration 4										

SCF (Solar Cooling Load Factor) Values

	106A	102A	102	101 + Conf	101A	101B	100	110/110A	113	114
Skylight										
Fenestration 1	41	38				38				
Fenestration 2	41									
Fenestration 3	41									
Fenestration 4	41									

HVAC Calculations

Room No.:	106A	102A	102	101 + Conf	101A	101B	100	110/110A	113	114	
Room Name:											
CLF (Cooling Load Factor) Values											
People - Type 1	0.89	0.89	0.89	0.89		0.89	0.89				
People - Type 2											
Lights - Type 1	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	
Lights - Type 2											
Equipment 1	0.89	0.89	0.89	0.89		0.89	0.89				
Equipment 2	0.89	0.89	0.89	0.89		0.89	0.89				
Equipment 3	0.89	0.89	0.89	0.89		0.89	0.89				
F_U Use Factors											
People - Type 1	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	
People - Type 2	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	
Lights - Type 1	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	
Lights - Type 2	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	
Equipment 1	0.40	0.70	0.70	0.70		0.70	0.70				Technology
Equipment 2	0.42	0.34				0.25	0.25				Kitchen
Equipment 3	0.25										Other

OUTPUT

Cooling Load (Summer - Sensible)

	System Totals	106A	102A	102	101 + Conf	101A	101B	100	110/110A	113	114
Roof	68,230	24,888	2,081	2,081	11,893	1,673	3,366	9,976	7,784	3,611	877
Skylight - Transmission	0	0	0	0	0	0	0	0	0	0	0
Skylight - Solar	0	0	0	0	0	0	0	0	0	0	0
Exposed Floor	20,949	9,052	557	557	3,183	608	901	2,670	1,788	1,313	319
Walls	274	119	0	0	30	0	26	0	98	0	0
Fenestration - Transmission	276	92	92	0	0	0	92	0	0	0	0
Fenestration - Solar	0	0	0	0	0	0	0	0	0	0	0
Doors	0	0	0	0	0	0	0	0	0	0	0
Ceiling/Parition 1	0	0	0	0	0	0	0	0	0	0	0
Other Paritions	0	0	0	0	0	0	0	0	0	0	0
People	4,673	2,670	167	167	1,001	0	250	417	0	0	0
Lights	3,834	727	242	242	606	61	242	1,350	121	182	61
Equipment	30,716	24,263	1,907	463	1,466	0	690	1,927	0	0	0
Total Heat Load (BTU/Hr)	128,951	61,812	5,046	3,510	18,180	2,342	5,568	16,340	9,792	5,106	1,257
Load with Safety Factor	128,951	61,812	5,046	3,510	18,180	2,342	5,568	16,340	9,792	5,106	1,257
BTU/Hr/SF		51	49	34	31	29	34	33	41	29	29
Max cfm	5,970	2,860	230	160	840	110	260	760	450	240	60
Min cfm	1,800	860	70	50	250	30	80	230	140	70	20
Max cfm/sf	17	2.3	2.3	1.6	1.4	1.3	1.6	1.6	1.9	1.4	1.4
Min cfm/sf	5	0.7	0.7	0.5	0.4	0.4	0.5	0.5	0.6	0.4	0.5

Cooling Load (Summer - Latent)

People	3,360	1,920	120	120	720	0	180	300	0	0	0
Equipment	0	0	0	0	0	0	0	0	0	0	0
Total	3,360	1,920	120	120	720	0	180	300	0	0	0

Heat Loss (Winter)

	System Totals										
Roof	0	0	0	0	0	0	0	0	0	0	0
Skylight	0	0	0	0	0	0	0	0	0	0	0
Exposed Floor	0	0	0	0	0	0	0	0	0	0	0
Slab Edge	0	0	0	0	0	0	0	0	0	0	0
Below Gr Walls	0	0	0	0	0	0	0	0	0	0	0
Below Gr Floor	0	0	0	0	0	0	0	0	0	0	0
Walls	0	0	0	0	0	0	0	0	0	0	0
Fenestration	0	0	0	0	0	0	0	0	0	0	0
Doors	0	0	0	0	0	0	0	0	0	0	0
Ceiling /Partition 1	0	0	0	0	0	0	0	0	0	0	0
Other Partitions	0	0	0	0	0	0	0	0	0	0	0
Total Infiltration CFM	946	176	81	79	100	78	84	93	97	82	77
Infiltration BTU/Hr	-68,485	-12,761	-5,867	-5,704	-7,237	-5,650	-6,070	-6,754	-6,993	-5,907	-5,544
Total Heat Loss (BTU/Hr)	-68,485	-12,761	-5,867	-5,704	-7,237	-5,650	-6,070	-6,754	-6,993	-5,907	-5,544
Load with Safety Factor	-85,606	-15,951	-7,333	-7,130	-9,046	-7,062	-7,588	-8,442	-8,741	-7,384	-6,930
BTU/Hr/SF		-13	-72	-70	-16	-86	-46	-17	-36	-42	-161
LAT for Max cfm		77.2	101.5	113.3	82.0	131.4	99.0	82.3	90.0	100.5	178.9
LAT for Min cfm		89.2	169.0	204.0	105.5	290.0	159.8	106.0	129.8	169.7	392.8
CFM for Max Htg LAT		642	295	287	364	284	305	340	352	297	279
Reheat + Heating (BTU/Hr)	-18,332	-161	-1,913	-1,860	-2,360	-1,842	-1,979	-2,202	-2,280	-1,926	-1,808

Equipment:

remember to use conversion for AC current

1 “Desktop” = 1 computer + 2 screen = 200W
1 Computer =150W
1 monitor = 50W
1 avg projector = 275W https://files.support.epson.com/htmldocs/bl475wi/bl475wiug/source/specifications/reference/pl470_bl485wi/spex_electrical_pl470_bl485wi.html

Television Screen: 70” LED = 415 W
Office Copier: 1100 W
Small Printer: avg(3.75+14) W https://store.hp.com/us/en/pdp/hp-envy-5055-all-in-one-printer

Mini Fridge: 1.5*sqrt(3)*115 = 300 W https://www.bestbuy.com/site/insignia-2-6-cu-ft-mini-fridge-black/6145102.p?skuId=6145102

Cold Vending Machine: 115*sqrt(3)*11 = 2200W https://www.vending.com/vending-machines/drink-machines/36-selection-soda-drink-vending-machine/

Food Vending Machine: 1.2*115*sqrt(3) = 240W https://www.vending.com/vending-machines/snack-machines/32-selection-snack/

Ice Maker: 330 W https://www.amazon.com/dp/B07SSF371B/ref=sspa_dk_detail_0?psc=1

Drinking fountain: 370W https://www.amazon.com/dp/B001DEN91E/ref=sspa_dk_detail_2?psc=1&pd_rd_i=B001DEN91E&pd_rd_w=wAH2Z&pf_rd_p=8a8f3917-7900-4ce8-ad90-adf0d53c0985&pd_rd_wg=xUDyf&pf_rd_r=MWFT32GF4WKK7NQ206SQ&pd_rd_r=610bcfeb-a4e9-11e9-b3cf-c7b347a57761

Break Room:

https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=11&ved=2ahUKEwjpzOLM7aXjAhWyCTQIHWWyATEQFjAKegQIARAC&url=https%3A%2F%2Ftimomarquez.files.wordpress.com%2F2011%2F08%2Fcalorequipos.pdf&usg=AOvVaw23u5HniRNS4gfleIzMtPBd

1 Fridge: 2.1 m^3 * 310W = 650
1 Coffee brewer: 1100 W each
2 medium microwaves: 1000 watts each
Total Watts: 2750 W

Kitchenette:

Skillet + Oven = 12,180 W
Total + break room = 14,930 W

Usage Factor: 0.42

General Generalizations:

Window: 4x4'
Ceiling = 3/4" Acoustical tile
Air Space above ceiling = 8 ft
Roof = 0.1" metal deck
Lighting for large spaces = fluorescent 4-lamp
Lighting for small spaces = fluorescent 2-lamp
Office flooring is 6" concrete with carpet
All other flooring 6" concrete only

Fu Factors:

Fridge/Mini fridge = .25
Oven/stovetop = .2
Coffee Pot = .09
Office Technology = .7
Cold Vending Machine = .25
Conference Room Tech= .4
People 0.375
Lighting 0.375

C.2 TA-03-0223 HEAT LOAD CALCULATION FACTORS (ASHRAE)

Wall U-factor Calculations

Project:	0223 HVAC Renovation						
Project No.:							
Date:	Summer 2019						
Calcs By:	Matney Juntunen						
Wall 1	Description						
Thickness			**k-factor**	**Density**	**Summer**	**Winter**	**Mass**
(Inches)	**Item**	**Reference**	**BTU-in/Hr-sf-F**	**Lbs/ft3**	**R - Value**	**R - Value**	**(lbs/sf)**
-	Outside Air Film	2017 ASHRAE F26.		0.057	0.25	0.17	0.0
	Wood Siding		0.375	22	-	-	0.0
	Face Brick		4.55	50	-	-	0.0
	Precast Concrete		3.3	80	-	-	0.0
	Stucco		0.55	25	-	-	0.0
	Concrete Block (4, 8, or 12")		4.71	55	-	-	0.0
	Filled Concrete Block (6,8,or12")		4.71	56	-	-	0.0
	Concrete		9.0	140	-	-	0.0
	Clay Tile (3,4,6,8,10, or 12")		3.6	40	-	-	0.0
	Glass Spandrel Panels (1")		1.7	39.5	-	-	0.0
	Air Space				0.00	0.00	0.0
	Plywood		0.63	34	-	-	0.0
	Gypsum Board		1.1	40	-	-	0.0
	Extruded Polystyrene R-5/in		0.2	1.4	-	-	0.0
	Expanded Polystyrene R-4/in		0.25	1.0	-	-	0.0
	Cellar Polyurethane R-6.25/in		0.16	1.9	-	-	0.0
	Polyisocyanurate R-7.04/in		0.14	1.6	-	-	0.0
	Air Space				0.00	0.00	0
	Fiberglass Batt & Wood Studs		0.40	3.79	-	-	0.0
6.75	Fiberglass Batt & Metal Studs		0.37	2.74	18.44	18.44	1.5
	Plywood or Hardboard		0.63	34	-	-	0.0
1.25	Gypsum Board		1.1	40	1.14	1.14	4.2
	Gypsum Plaster		0.55	70	-	-	0.0
1.00	Fiberglass board		0.027		37.04	37.04	
-	Inside Air Film				0.68	0.68	0.0
Total R-Value =					**57.55**	**57.47**	
U-Factor = 1/R =					**0.0174**	**0.02**	
Wall Mass (lbs/sf)							5.7

Roof U-factor Calculations

Project:	0223 HVAC Renovation
Project No.:	
Date:	Summer 2019
Calcs By:	Matney Juntunen

Roof 1 Description

Thickness (Inches)	Item	Reference	k-factor BTU-in/Hr-sf-F	Density Lbs/ft3	Summer R - Value	Winter R - Value	Mass (lbs/sf)
-	Outside Air Film	2017 ASHRAE F26.		0.057	0.25	0.17	0.0
	Wood Shingles (Up to 3/8")		0.375	22	-	-	0.0
	Asphalt Shingles (1/8")		2.98	100	-	-	0.0
	Ballast/Membrane Roof (0.1")		8.33	60	-	-	0.0
	Slate (Up to 1/2")		10	150	-	-	0.0
	Built-up Roofing (3/8")		1.14	70	-	-	0.0
0.1	Metal Deck (0.1")		314.4	489	0.00	0.00	4.1
	Precast Concrete Planks(8 or10")		4.71	55	-	-	0.0
	Concrete		9.0	140	-	-	0.0
	Plywood		0.63	34	-	-	0.0
	Gypsum Board		1.1	40	-	-	0.0
	Extruded Polystyrene R-5/in		0.2	1.4	-	-	0.0
	Expanded Polystyrene R-4/in		0.25	1.0	-	-	0.0
	Cellar Polyurethane R-6.25/in		0.16	1.9	-	-	0.0
	Polyisocyanurate R-7.04/in		0.14	1.6	-	-	0.0
	Air Space				0.00	0.00	0.0
	Fiberglass Batt		0.3158	1.8	-	-	0.0
192.0	Air Space			0.057	1.44	0.77	0.0
	Plywood or Hardboard		0.63	34	-	-	0.0
	Gypsum Board		1.1	40	-	-	0.0
	Gypsum Plaster		0.55	70	-	-	0.0
0.63	Acoustical Tile		0.36	21	1.50	1.50	1.1
-	Inside Air Film				0.92	0.61	0.0
Total R-Value =					**4.11**	**3.05**	
U-Factor = 1/R =					**0.24**	**0.33**	
Roof Mass (lbs/sf)							5.2

Floor U-factor Calculations

Project:	0223 HVAC Renovation
Project No.:	
Date:	Summer 2019
Calcs By:	Matney Juntunen

Floor 1 Description

Thickness (Inches)	Item	Reference	k-factor BTU-in/Hr-sf-F	Density Lbs/ft3	Summer R - Value	Winter R - Value	Mass (lbs/sf)
I	Inside/Outside Air Film (I or O)	2017 ASHRAE F26.		0.057	0.61	0.92	0.0
	Precast Concrete Planks(8 or10")		4.71	55	-	-	0.0
	Concrete		9.0	140	-	-	0.0
	Metal Deck (0.1")		314.4	489	-	-	0.0
	Plywood		0.63	34	-	-	0.0
	Gypsum Board		1.1	40	-	-	0.0
	Extruded Polystyrene R-5/in		0.2	1.4	-	-	0.0
	Expanded Polystyrene R-4/in		0.25	1.0	-	-	0.0
	Cellar Polyurethane R-6.25/in		0.16	1.9	-	-	0.0
	Polyisocyanurate R-7.04/in		0.14	1.6	-	-	0.0
	Air Space				0.00	0.00	0.0
	Fiberglass Batt		0.3158	1.8	0.00	0.00	0.0
	Air Space				0.00	0.00	0.0
	Precast Concrete Planks(8 or10")		4.71	55	-	-	0.0
6.0	Concrete		9.0	140	0.67	0.67	70.0
	Plywood		0.63	34	-	-	0.0
	Carpeting (3/8")		0.55	20	-	-	0.0
	Terazzo (1")		12.50	120	-	-	0.0
	Tile -Linoleum/cork (1/4")		0.49	29	-	-	0.0
-	Inside Air Film				0.61	0.92	0.0
Total R-Value =					**1.89**	**2.51**	
U-Factor = 1/R =					**0.53**	**0.40**	
Floor Mass (lbs/sf)							70.0

Ceiling Partition U-factor Calculations

Project:	0223 HVAC Renovation
Project No.:	
Date:	Summer 2019
Calcs By:	Matney Juntunen

Partition 1 Description

Thickness (Inches)	Item	Reference	k-factor BTU-in/Hr-sf-F	Density Lbs/ft3	Summer R - Value	Winter R - Value	Mass (lbs/sf)
-	Inside Air Film	2017 ASHRAE F26.		0.057	0.92	0.61	0.0
	Precast Concrete		3.3	80	-	-	0.0
	Concrete		9.0	140	-	-	0.0
	Plywood		0.63	34	-	-	0.0
	Gypsum Board		1.1	40	-	-	0.0
	Air Space				0.00	0.00	0
	Fiberglass Batt & Wood Studs		0.40	3.79	-	-	0.0
	Fiberglass Batt & Metal Studs		0.37	2.74	-	-	0.0
	Plywood or Hardboard		0.63	34	-	-	0.0
	Gypsum Board		1.1	40	-	-	0.0
	Gypsum Plaster		0.55	70	-	-	0.0
	Acoustical Tile		0.36	21	-	-	0.0
-	Inside Air Film				0.92	0.61	0.0
Total R-Value =					**1.84**	**1.22**	
U-Factor = 1/R =					**0.54**	**0.82**	
Partition Mass (lbs/sf)							0.0

CLTD/SCF/CLF Lookup Tables

A. Project Data

1.	Project Latitude:	35.6	degN (+ values for North latitudes. Use - values for South latitudes)
2.	Design Temperatures		
a.	Outside	89	degF maximum
		20	degF average daily range of highest - lowest temperature
b.	Inside	72	degF
3.	Wall Construction		
a.	Wall Type	1	See Table 1 below
b.	Siding Type	1	See Table 2 below
c.	R-value	57.55	hr-sf-oF/BTU
d.	Insulation Location	0	(0=Insulation evenly distributed, 1=Inside of mass, 2=Outside of mass)
4.	Roof Construction		
a.	Roof Type #	1	(1=steel deck+insulation, 2 = 1"wood deck + insulation, 3= 2" or more of concrete deck + insulation)
b.	R-value	4.69	hr-sf-oF/BTU
c.	Insulation Location	1	(1 = Inside of deck, 2=Outside of deck)
d.	Suspended Ceiling?	Y	(Y=Yes, N= No)
e.	Attic?	Y	(Y=Yes, N= No)
5.	Interior Construction		
a.	Carpet?	Y	(Y/N) N= vinyl flooring or bare concrete floors
b.	Partition Type	1	1 = Gypsum board, 2 = concrete block
c.	Inside Shades?	N	(Y/N)
d.	Small or large zones at perimeter	2	1 = Small (<200 sf) , 2 = large, >200 sf
e.	Multiple stories?	N	(Y/N)
f.	Floor Type	1	1 = concrete (cast-in-place or concrete on metal decking, 2 = wood framed floors)
6.	Building Schedules		
a.	People	10	hours/day - average
b.	Lights	8	hours/day - average
c.	Equipment	10	hours/day - average

TABLE 1 - Wall Types

Wall Type #	Lbs/SF	ASHRAE #	General Description
1	3.1	B7	1" wood, metal framed
2	6.2	B10	2" wood, wood framed
3	9.7	A1	1" Stucco
4	12.0	C17	8" LW concrete block - filled
5	12.3	B9	4" wood
6	12.7	C2	4" LW concrete
7	20.3	C3	4" HW concrete
8	23.3	C1	4" clay tile
9	35.4	C18	8" HW concrete block - filled
10	40.0	C4	4" common brick
11	40.7	C7	8" LW concrete block
12	41.7	A2	4" face brick
13	46.7	C5	4" HW concrete
14	46.7	C6	8" clay tile
15	93.4	C8	8" HW concrete block

TABLE 2 - Siding Types (Outside Surface)

Siding Type #	Lbs/SF		General Description
1	1	LW	Light weight - Siding (steel, wood)
2	9.7	SP	Medium weight - Stucco or Plaster
3	41.7	FB	Heavy Weight - Face Brick, precast

Notes -

1 Data taken from 1997 ASHRAE Handbook of Fundamentals, Chapter 18 for CLTD, SCF, and CLF.

Wall CLTD Values

Correction Factor applied to table = 0 degF

Search Criteria					
ASHRAE Wall No.	Wall Type	Siding Type	Insulation Location	Max R-Value	Latitude
4	B7	LW	Even	27	32

Wall CLTD Values

Wall Direction	July 21st Hour											
	9	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
N	3	5	7	10	14	17	20	24	29	26	27	27
NE	14	35	39	34	34	33	32	30	29	29	28	26
E	15	27	39	46	51	48	45	40	36	34	32	29
SE	7	15	23	29	42	46	47	44	39	37	34	30
S	0	1	4	10	15	21	26	39	41	42	39	35
SW	1	2	5	6	10	16	22	33	42	53	57	57
W	1	2	5	8	11	15	21	30	39	51	60	64
NW	0	2	4	8	15	25	22	25	31	37	45	49

Wall CLTD Values

Wall Direction	October 21st Hour											
	9	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
N	2	4	6	8	10	12	14	13	8	7	7	7
NE	6	13	22	26	26	24	23	19	12	7	7	7
E	15	27	36	36	39	36	43	25	15	9	8	7
SE	10	23	39	60	75	42	35	28	16	9	9	8
S	0	4	11	22	35	54	81	103	48	11	10	9
SW	1	2	9	13	17	24	35	44	35	13	14	14
W	1	2	4	6	10	15	21	28	24	13	15	16
NW	0	2	3	6	8	9	9	13	13	9	11	12

Notes

CLTD corrected = (78-T inside) + (T oa design - daily range/2)-85)

Correcetd for latitude

Data from 1997 ASHRAE Handbook of Fundamentals, Chapter 28, Tables 32 and 33A, 33B, 33C.

Roof CLTD Values

Correction Factor applied to table = 0 degF

Search Criteria					
ASHRAE Roof No.	Mass Location	Suspended Celing	Max R-Value	Roof Description	Latitude
2	Evenly Placed	With	15	Steel Deck	32

Roof CLTD Values for Selected Roof Type

Month	9	10	11	12	13	14	15	16	17	18	19	20
July 21st	17	33	50	64	76	84	87	85	75	70	56	39
Oct. 21st	12	26	41	53	63	67	63	49	27	18	14	10

Notes

CLTD corrected = (78-T inside) + (T oa design - daily range/2)-85)
Corrected for latitude
Data from 1997 ASHRAE Handbook of Fundamentals, Chapter 28, Tables 30 and 31.

Glass CLTD Values

Correction Factor applied to table = 0 degF

Glass CLTD Values												
Wall Direction	Hour											
	9	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
All	2	4	7	9	12	13	14	14	13	12	10	8

Notes
CLTD corrected = (78-T inside) + (T oa design - daily range/2)-85)
Data from 1997 ASHRAE Handbook of Fundamentals, Chapter 28, Table 34.

Glass SCL Values

Search Criteria					
ASHRAE Zone Type	Zone Size	Flooring	Partition Type	Inside Shading	Latitude
A	Large	Carpet	Gypsum	N	32

Glass SCL Values

Wall Direction	July 21st Hour											
	9	10	11	12	13	14	15	16	17	18	19	20
N	34	37	40	42	42	41	38	35	39	36	12	6
NE	136	139	80	52	46	41	38	32	25	18	7	3
E	185	156	109	69	56	46	40	33	25	18	7	3
SE	114	126	102	70	60	49	42	34	26	18	7	3
S	27	42	55	64	62	55	41	39	30	20	8	4
SW	31	35	36	29	51	96	120	169	172	156	57	27
W	31	36	40	41	67	116	160	188	186	156	57	27
NW	31	36	40	43	58	93	102	133	147	130	46	22
Horizontal	172	219	251	268	270	255	221	176	115	70	29	14

Glass SCL Values

Wall Direction	October 21st Hour											
	9	10	11	12	13	14	15	16	17	18	19	20
N	20	24	28	29	29	27	23	14	4	0	0	0
NE	35	35	37	35	32	27	24	16	5	0	0	0
E	183	155	99	49	39	31	38	17	5	0	0	0
SE	211	221	209	183	125	44	28	17	5	0	0	0
S	114	145	173	191	195	190	174	126	35	0	0	0
SW	20	31	75	76	104	168	222	241	129	0	0	0
W	29	24	28	29	61	115	158	170	87	0	0	0
NW	19	24	28	29	27	23	26	52	38	0	0	0
Horizontal	109	158	193	209	207	183	140	76	14	0	0	0

Notes

Data from 1997 ASHRAE Handbook of Fundamentals, Chapter 28, Tables 35A, 35B, and 36.
Data corrected for latitude and Month based on SHGF in 1997 ASHRAE Handbook of Findamentals, Chapter 29

PEOPLE AND UNHOODED EQUIPMENT CFL VALUES

Search Criteria				
ASHRAE Zone Type	Zone Size	Flooring	Partition Type	Inside Shading
B	Large	Carpet	Gypsum	N

People CLF Values												
Hours in Space	Hour after entry											
	1	2	3	4	5	6	7	8	9	10	11	12
10	0.65	0.75	0.81	0.85	0.89	0.91	0.93	0.95	0.96	0.97	0.33	0.24

Unhooded Equipment CLF Values												
Hours of Operation	Hour after start											
	1	2	3	4	5	6	7	8	9	10	11	12
10	0.65	0.75	0.81	0.85	0.89	0.91	0.93	0.95	0.96	0.97	0.33	0.24

Notes

Data from 1997 ASHRAE Handbook of Fundamentals, Chapter 28, Tables 35A, 35B, and 37.

LIGHTING CFL VALUES

Search Criteria				
ASHRAE Zone Type	Zone Size	Flooring	Partition Type	Inside Shading
B	Large	Carpet	Gypsum	N

Lighting CLF Values												
	Hour After Lights Turned On.											
Hr/Day On	1	2	3	4	5	6	7	8	9	10	11	12
8	0.75	0.85	0.9	0.93	0.94	0.95	0.95	0.96	0.23	0.12	0.08	0.05

Notes

Data from 1997 ASHRAE Handbook of Fundamentals, Chapter 28, Tables 35A, 35B, and 38.

Glass U-factor Adjustments

Project:	03-0223 Heat Calcs
Project No.:	
Date:	Summer 2019
Calcs By:	Matney Juntunen

Description

INPUT DATA

Frame Outside Dimension

Total Length	48	Inches
Total Height	48	Inches
Width of frame element	0	Inches

No. of horizontal panes	1
No. of vertical panes	1

U-Factors

U center of glass	0.3	BTU/Hr-sf-^{o}F
U frame	1.32	BTU/Hr-sf-^{o}F

OUTPUT DATA

Area of frame	0	sq. in.	0.0%
Area of edge glass	480	sq. in.	20.8%
Area of center of glass	1824	sq. in.	79.2%
Area - total of glass + frame	2304	sq. in.	100.0%
U-factor edge of glass	0.81	BTU/Hr-sf-^{o}F	
U-factor total adjusted	**0.41**	**BTU/Hr-sf-^{o}F**	